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Passenger Transport Charges

At the end of last week details were published of the draft Passenger Charges Scheme, 1951, which the British Transport Commission has submitted to the Transport Tribunal. The scheme deals with all passenger fares on London Transport services and on British Railways, including fares in the London area which were the subject of the scheme which came into operation last October. The proposals provide for an increase from 1¼d. to 1½d. a mile on London Transport road vehicles and trains, an increase in the early morning single fares by road, and increases of approximately 20 per cent on season tickets, and early morning rail return fares. On London Transport coaches the increased fare suggested is from 1¼d. to 1½d. a mile. The scheme for British Railways envisages increases of about 20 per cent on early morning return fares and season tickets and of approximately 10 per cent on monthly return fares. No change is proposed for ordinary single fares, the present rate of which is slightly under 2¼d. a mile, or for boat train fares. It is recommended, however, that shift workers' fares and traders' season tickets on British Railways should be withdrawn, that a number of cheap day, excursion and other reduced fares should be increased, and that the discount on bulk travel and commercial travellers' tickets should cease. In a statement explaining the proposed increases, Lord Hurcomb, chairman of the British Transport Commission, said that the first three years of the Commission's existence had produced an accumulated deficiency of approximately £40,000,000, and it had not been possible to start building up the general reserve required by the Transport Act. Mainly as a consequence of various awards and settlements, the wages bill increased sharply towards the end of last year, as did the price of commodities of which the Commission was a large user. Early in the present year, Lord Hurcomb pointed out, the Commission was faced with a deficit on its net revenue account for 1951 of about £25,000,000, and the increased freight charges, authorised by the Minister of Transport to operate as from April 16th, would not yield more than £15,000,000 in the current year.

The F.B.I. and Railway Freight Charges

On Thursday of last week, the Federation of British Industries issued the text of a letter, which it has addressed to the Minister of Transport, protesting on behalf of productive industry against the decision to increase railway freight charges by 10 per cent as from April 16th. The letter said that there was general regret that the recent railway wages award was not definitely linked with the attainment of greater efficiency, in spite of the unanimous recommendation to that effect by the Court of Inquiry. The F.B.I. considered that the mere passing on of increased costs to the transport user would not of itself remedy the basic problems, for, it claimed, traffic would continue to drift from the railways to other means which would provide cheaper rates and more efficient service. The inevitable consequence in the long term would be a continuing need to underpin railway finances by large subsidies at the cost of the taxpayer. The letter went on to suggest that, despite increased charges, the railway service was less prompt and efficient than in pre-war days, transit times were generally longer, and there had been greater damage to goods through pilferage and carelessness. The right policy, the F.B.I. asserted, must surely be for the railways to concentrate on those services which they could perform more efficiently than other means of transport. Uneconomic and redundant facilities should be given up, and it was suggested that a use of modern methods of work study would disclose further ways in which railway costs per unit of traffic handled could be lowered and charges reduced. Commenting on the Federation's protest, Mr. John Elliot, chairman of the Railway Executive, regretted the wholly critical tone of the letter. He said that—because of export demands—deliveries of rolling stock ordered by the Executive were months behind schedule, and added that an indication of general standards of railway operating efficiency was that there were fewer locomotives and wagons under and awaiting repair now than ever before in railway history.

An Iron and Steel Productivity Team

The Anglo-American Council on Productivity has made arrangements for a productivity team from the British iron and steel industry to make a six weeks' tour in the U.S.A. The team will cover pig iron and heavy steelmaking, and will study and report on the organisation and methods of the American iron and steel industry. It will also consider the factors bearing on the comparative productivity of the British and United States industries, with a view to recommending whether and by what methods American experience can with benefit be applied or adapted to this country. Much, of course, is already known over here about the American iron and steel industry, but it is nevertheless felt that a fuller interchange of information and a first-hand examination of the relevant wide variations of practice and conditions to be found in the U.S.A. will be of benefit to development here. The team, which is booked to sail on May 17th, will be led by Sir Charles Goodeve, F.R.S., Director of the British Iron and Steel Research Association.

The Association of Supervising Electrical Engineers

The annual dinner and reunion of the Association of Supervising Electrical Engineers was held at the Connaught Rooms, London, on Friday, April 13th. Proposing the toast of "The Electrical Industry," Sir Stanley Angwin, chairman of the Commonwealth Telecommunications Board, spoke of the difficult task that the industry must face in the effort to graft production for defence on to the existing needs of the home and export market. One of the difficulties was that of upholding the industry's standards of craftsmanship and apprenticeship, and the Association, by the stimulus that it gave to training, was making a useful contribution towards a solution of the problem. Sir Archibald Gill, President of the Institution of Electrical Engineers, who responded to the toast, referred to some of the production achievements of the electrical industry. In three years the manufacture of electrical generating plant had been increased by 50 per cent. In the five years since the war the output of radio components had increased fivefold, while exports had increased twelvefold, until the United Kingdom was the world's largest exporter of radio components. In many of its spheres of activity the Association had given invaluable assistance to the Institution of Electrical Engineers—particularly in its efforts to provide for the training of technicians, and in the framing of the I.E.E. Regulations for the Electrical Equipment of Buildings. The toast of "The Guests" was proposed by Mr. T. G. N. Haldane, the president of the Association, and Sir Harold Hartley, chairman of the Electricity Supply Research Council, responded. To conclude the more formal part of the evening's proceedings, the president made a presentation of a silver salver to Professor R. O. Kapp in appreciation of his services as chief examiner for the Association's diploma scheme—an office which has now been handed on to Dr. F. T. Chapman.

Steam Piping for High Pressures

At a general meeting of the Institution of Mechanical Engineers, held in London last Friday evening, a paper on "Steam Piping for High Pressures and High Temperatures" was presented by Dr. R. W. Bailey, F.R.S., Vice-President. In his paper, Dr. Bailey suggested that steam piping had hardly kept pace in scientific design, and in the consequent economic use of materials, with turbine development for high temperatures and pressures. As a result, piping systems had commonly been more costly and heavier than had been necessary. The purpose of the paper was to draw attention to the more important factors which operated in piping, where, because of the temperature and stress, creep behaviour dominated design, and to indicate the application to be made of the underlying scientific principles. According to Dr. Bailey, the principal matters requiring consideration were: stresses developed as a result of creep, and the creep strain allowable for design; the design temperature needed to provide for the rated temperature and pressure together with the allowed fluctuations in pressure and temperature; the influence of creep in removing the thermal expansion loading of a pipe-line at operating temperature and in imposing it wholly when the system was cold, when creep determined design; bolted or otherwise removable joints at terminal or other special positions, and measures to minimise joint loading; materials and corrosion, and piping for less advanced conditions.

Raw Material Supplies

During the resumed debate on the Budget proposals, in the House of Commons on Monday last, the President of the Board of Trade, Mr. Harold Wilson, said that the raw materials position was the most serious problem affecting productivity. So far as sulphur was concerned, there was some hope that, in the current quarter, this country might receive an allocation of 100,000 tons, compared with the totally inadequate figure of 81,000 tons in the first quarter. But the 100,000 tons figure was by no means certain. Essential production, Mr. Wilson stated, was being interfered with, and the Government therefore intended at the beginning of next month to introduce an allocation system, industry by industry, of both sulphur and sulphuric acid. If by then the 100,000 tons allocation was certain, it would be possible to avoid some of the worst disasters that had been feared, though the position would still be most serious, and reductions would have to be made in a number of industries. Mr. Wilson added that an allocation of something like 110,000 tons of sulphur this quarter might enable industrial production in this country to be maintained at a reasonable level, and therefore, if we got 100,000 tons, we should be considerably short; if we got no more than 81,000 tons the country would be facing a disastrous situation. He went on to speak of non-ferrous metals, particularly molybdenum, tungsten, nickel, copper and zinc, saying that not only general industrial production, but the defence programme itself would be in the gravest danger unless, as a result of international discussions now proceeding in Washington, larger allocations of those metals were made available to this country.

Historic Development of the Theory of the Flow of Water in Canals and Rivers*

By SERGE LELIAVSKY BEY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. II—(*Continued from page 468, April 13th*)

A NEW era in the study of turbulent flow began in the earlier years of this century with the findings of Professor Ludwig Prandtl, creator and head of the "Göttingen School." In fact, Prandtl's discovery of the laminar boundary layer[18] is usually considered as the origin of "Fluid Mechanics." From about 1920 onwards, Prandtl's work was paralleled by the work of his disciple, von Karman, so that at present it is customary to designate the findings of the new theory by the joint names of both authors.

Better to set out the specific characteristics of the Prandtl-Karman theoretically-derived scala, we must first give a few introductory remarks on the theoretical approach to the

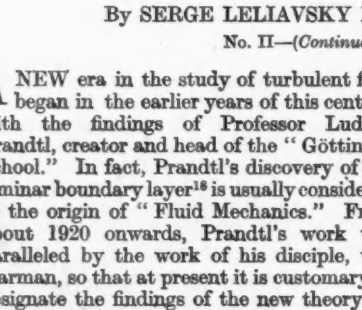


FIG. 8

scala problem in general, and explain how the earlier parabolic curves were obtained.

There is one point about this theory which should always be borne in mind, namely that in all cases of uniform flow, whether laminar or turbulent, whether in closed conduits or in open channels, the shearing stress always varies linearly. Note that under the term "uniform flow" is meant the case when the velocity in any normal section *AB* or *CD* of the channel or conduit is always the same (see Fig. 8). Natural streams, within the limits of the usual assumptions of everyday engineering practice, are commonly considered as uniform, provided no barrage or dam is built over them, or provided a section not affected by the back-water of such a barrage is considered. In such streams, therefore, we may approximately assume the shear to vary linearly, as shown in Fig. 8, though this assumption must naturally refer to average values only.

In the case of a pipe, the assumption will be closer to Nature, but so long as the flow is turbulent, the principle will be true in the statistical sense only. In laminar flow, on the other hand, it will be an exact law (applicable to both average and instantaneous values).

Owing to the importance of the principle, there is reason enough to explain its development. Consider the horizontal forces applied to the infinitesimal cube *abcd* in Fig. 9. They are the normal hudraulic pressures, $p\Delta y\Delta z$, and $\left(p+\frac{dp}{dx}\Delta x\right)\Delta y\Delta z$, on its vertical faces, and the tangential shearing forces, $\tau\Delta x\Delta z$ and $\left(\tau+\frac{d\tau}{dy}\Delta y\right)\Delta x\Delta z$, on its horizontal faces. Since in uniform flow there is no accelerating effect, these forces must balance each other. It follows :—

$$p\Delta y\Delta z+\left(\tau+\frac{d\tau}{dy}\Delta y\right)\Delta x\Delta z=\tau\Delta x\Delta z$$
$$+\left(p+\frac{dp}{dx}\Delta x\right)\Delta y\Delta z.$$

Resolving

$$\frac{d\tau}{dy}\Delta y\Delta x\Delta z=\frac{dp}{dx}\Delta x\Delta y\Delta z.$$

Dividing by $\Delta y\Delta x\Delta z$

$$\frac{d\tau}{dy}=\frac{dp}{dx}.$$

Now, since in uniform flow there is no change of velocity from section to section, it follows that the pressure gradient, $\frac{dp}{dx}$, must remain unchanged. Hence $\frac{d\tau}{dy}$ is also a constant.

This conclusion leads directly to a very simple and accurate solution of the scala problem for laminar flow, since in this case the viscosity μ is a constant, which means that the rate of change of the velocity $\frac{dv}{dy}$ is proportional to the shearing stress τ,

$$\tau=\mu\frac{dv}{dy}.$$

It is quite obvious that in order to obtain v, we must integrate :—

$$\int\frac{\tau}{\mu}dy$$

and as the diagram of τ is a triangle, the result must necessarily be a parabola, Fig. 10.

Though this applies, strictly speaking, to laminar flow only, we shall, nevertheless, arrive at the same result in all cases if we

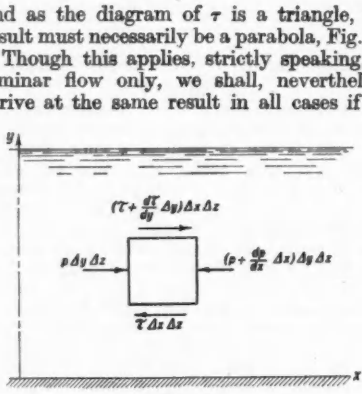


FIG. 9

disregard the difference in the equations due to streamlined and turbulent motions.

This argument explains the numerous unsatisfactory parabolic diagrams obtained theoretically by the earlier mathematicians. Even Boussinesq, in spite of having very clearly understood the mechanical significance of turbulence, and having replaced, therefore, in his equations the molecular viscosity μ by a specific coefficient embodying the eddy action, nevertheless assumed this coefficient to be constant—for the case of a very wide channel. Strangely enough, the same coefficient was taken to be inversely proportional to the radius, in the case of a circular section.

Instead of these purely abstract, i.e., speculative, assumptions of Boussinesq, the new theory, initiated by Prandtl, considers turbulence as a phenomenon capable of being quantitatively examined, on condition that we replace the instantaneous departures from the mean hydraulic values by average departures. It must be realised that though turbulence is essentially irregular, since even the most precise apparatus has failed to detect in it any traces of periodicity or resonance, it is, nevertheless, a fact that the intensity of turbulent action varies from point to point of a channel, and is a significant and measurable physical quantity, provided it is conceived, and expressed, as an average (in time).

In order, therefore, to arrive at quantitative results, Prandtl and Karman introduced a number of specific parameters, which are derived from, and define numerically, the average values characteristic of the turbulent effect. One such parameter, designated by the symbol η, is analogous to the term μ in the equation of laminar flow. It is termed "eddy viscosity," but is, of course, entirely different in regard to its physical interpretation from the "molecular viscosity" of the laminar equation. This parameter η

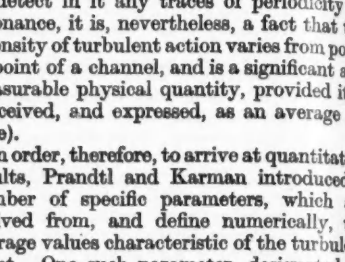


FIG. 10

which, like other modern turbulence parameters, is an average in time in the statistical sense of the word, eliminates the necessity for considering instantaneous departures from the mean. If $\bar{v}$ and $\bar{\tau}$ represent the average local velocity and the average local shear, we can then write :—

$$\bar{\tau}=\eta d\bar{v}/dy \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Experiments show that, in turbulent flow, the ratio of the average intensity of shear $\bar{\tau}$ to the eddy viscosity η is proportional to $\sqrt{\tau_o/\rho}$, where τ_o is the boundary shear, and inversely proportional to y. Thus

$$\frac{\bar{\tau}}{\eta}=2\cdot5\frac{\sqrt{\tau_o/\rho}}{y}.$$

Substituting this into (1) and integrating, we obtain the Prandtl-Karman logarithmic scala

$$\bar{v}=2\cdot5\sqrt{\frac{\tau_o}{\rho}}\log_e y+A=5\cdot75\sqrt{\frac{\tau_o}{\rho}}\log_{10}y+A \quad . \quad (2)$$

where A is the constant of integration.

It is rather significant that a logarithmic curve had also been obtained by Jasmund and Bolte on large rivers; for the experimental basis of the modern school of turbulence analysis is chiefly constituted by tests by Nicuradze, Stanton, Colebrook and White, and others, which were mostly carried out on very narrow pipes. The coincidence, therefore, of Jasmund's and Bolte's empirical results, obtained from a large river, with the new theory, lends further support to its achievements. The nature of the parameter η (eddy viscosity) requires, perhaps, to be more clearly explained, so as to avoid confusion with the molecular viscosity μ.

What is understood by "friction" or "shear" or "eddy viscosity," or various other allied concepts relating to the internal tangential effect of turbulent flow in open channels, is always due to a mixing process between the upper more rapidly moving

* The opinions expressed in this article are those of the author and do not necessarily represent those of the Egyptian Ministry of Public Works.

[18] Prandtl, "Uber Flussigkeitbewegung bei sehr Kleiner Reibung," International Mathematical Congress, Heidelberg, 1904.

layers and the slower layers at the bottom of the channel. This mixing produces an exchange of momentum resulting in a retarding effect in the upper part of the stream, and an accelerating action in the lower part. The general effect is, therefore, similar to that of molecular viscosity, but its intensity is far greater, and the mechanical laws controlling the phenomenon are, obviously, different. While the molecular viscosity remains constant throughout the entire volume of the moving water, the intensity of the mixing process, which determines the eddy viscosity, varies from point to point, depending chiefly on the two factors, the depth of penetration of the water particles from one layer into another, and the instantaneous deviations from the mean velocity.

In order to approach the problem from the quantitative statistical standpoint we must represent these factors by average parameters (in time).

In regard to the first, Prandtl introduced the concept of the "mixing length" l, a longitudinal parameter analogous to the "mean free path" of the molecular theory of gases. The parameter representative of the second is the root-mean-square, $\sqrt{\overline{v_1^2}}$, of the velocity deviations from the average velocity in a point. Note that squaring the velocity deviations for a certain period of time, and then taking the root of the mean square, is here a necessary mathematical operation, for these deviations vary considerably from positive to negative, and, therefore, their sum and average values are both zeros and could not be used as significant factors in the relevant equations. We must therefore square the deviations, so as to avoid negative and positive values.

The parameter η is characteristic of both flow and fluid. Dividing it by the fluid density ρ, we obtain a new coefficient ϵ, which characterises flow only, and we can, then, write :—

$$\epsilon = l\sqrt{\overline{v_1^2}}$$

from which

$$\eta = \rho l\sqrt{\overline{v_1^2}}\,.$$

This explains the physical nature of the coefficient η.

Another point in Prandtl-Karman's scala which also calls for comment is the mathematical equation of the curve itself, for the logarithmic formula gives zero velocity at a certain finite distance y_1 from the bottom, which, at the first glance, appears illogical. In the case, however, of a very smooth boundary surface, Prandtl has shown that the logarithmic curve in close vicinity to this surface loses its physical significance; for in this region it is replaced by a parabola, the reason being that under such conditions a laminar sub-layer intervenes between the zone of turbulent flow (for which the logarithmic curve is valid) and the smooth boundary. The theory of this sub-layer is of considerable importance for the general understanding of the problem, for it allows a deeper insight into the *hydraulic* interpretation of such terms as "friction" and "rugosity of channel," but it has no direct bearing on the scala problem in canals, since the essential condition for the occurrence of the sub-layer, viz., a very smooth channel, is here absent.

Further particulars about the laminar sub-layer will be given later on in discussing the "friction fallacy." At the present juncture, the application of the Prandtl-Karman logarithmic curve to what is described by them as "rough channels" is to be considered.

It is found experimentally that, for an artificially roughened surface (that is, a smooth basic surface on which sand particles of a definite, regular size have been cemented) the equation of the velocity curve bears a specific relation to the standard size of the cemented particles. In fact, the ordinate y_1 of the imaginary point in which the extension of the logarithmic curve below

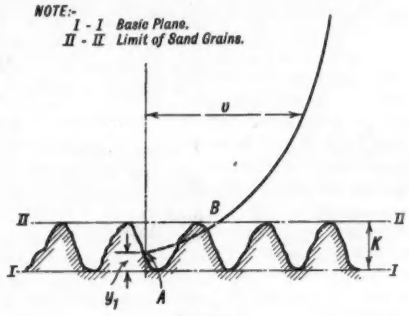


FIG. 11

the surface *II-II* (see Fig. 11) intersects the axis is found to be one thirty-third of the size, K, of the sand grains. This information may serve to find the constant of integration A in the equation of the curve

$$v = 5{\cdot}75\sqrt{\tau_0/\rho}\,\log_{10} y + A,$$

which, for sake of convenience, we may transcribe in the form

$$\frac{v}{\sqrt{\tau_0/\rho}} = 5{\cdot}75\,\log_{10}\frac{y}{y_1}\,.$$

Substituting in this $y_1 = \frac{K}{33}$

$$\frac{v}{\sqrt{\tau_0/\rho}} = 5{\cdot}75\,\log_{10}\frac{y}{K} + 8{\cdot}5.$$

This is the final scala-equation for a uniform sand roughness K, as determined by Nicuradze experiments.

As soon, however, as the size of the projections characteristic of the roughness ceases to be regular, the velocity distribution changes, for the larger irregularities interfere with the flow before the finer grain can ever become effective. It is, nevertheless, found experimentally that an equivalent size of projections K_1 may quantitatively be substituted for the various types of natural basically irregular surfaces. According to Hunter Rouse[19] the following equivalent sizes are approximately correct :—

Material	K_1 in feet	Material	K_1 in feet
Brass, copper, lead	0	Cast iron	0·00085
Wrought iron, steel	0·00015	Wood stave	0·00060 to 0·00300
Asphalted cast iron	0·00040	Concrete	0·00100 to 0·01000
Galvanised iron	0·00050	Riveted steel	0·00300 to 0·03000

Although these figures are obtained from experiments on new materials, the effect of age is supposed to be capable of being expressed by a linear function :—

$$K_1 = K_0 + \alpha t,$$

in which t is the time and α a constant, to be determined in each case *ad hoc*.

The period since the publication of these results has not been long enough for a verification of them by practical application to be regarded as exhaustive. There are, however, a number of instances that tend to confirm the new theory; for instance, according to observations by G. H. Hickox, A. J. Peterka and R. A. Elder on the Apalachia tunnel of the Tennessee Valley Authority,[20] the sizes of roughnesses calculated from the recorded discharges, according to Prandtl-Karman equations, were as follows :—

Tunnel surface	Pipe radius	Calculated size of roughness
Steel	9ft	0·0035in
Concrete	9ft	0·0400in
Rock...	11·3ft	22·0000in

The theoretically obtained figures, appearing in the last column of the table, were substantially in agreement with the true sizes of roughnesses characteristic of the three different types of culverts under observation; in fact, the steel surface was almost glassy, the concrete was slightly grainy (grain diameter from 0·03in to 0·06in), whilst for the rocky surface the figure 22in was by no means "out of line."

Further attention is next called to another parameter appearing in the quoted equations, namely, the mixing length l.

It has already been explained that the mixing of particles moving at different velocities is the essence of the modern concepts of "turbulent friction" and "turbulent shear." The "mixing length" is a characteristic of the intensity of such mixing,

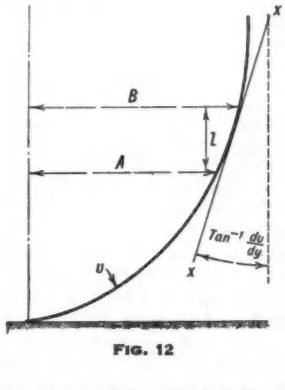


FIG. 12

for we must necessarily admit that a particle which has left a certain zone, with a velocity A—Fig. 12—after covering a certain path, l, loses its excess (or deficiency) of velocity and accommodates itself to the new velocity B, of the zone into which it has penetrated. The greater, therefore, the length of this path, and the greater the difference $A-B$, the more efficient will be the mixing process, i.e., the instantaneous effect of the velocity A on the velocity B.

For a gradually varying velocity curve the slope will be representative of the difference $A-B$.

On the other hand, the instantaneous departure v_1 of the velocity B from its average value can now be expressed as

$$v_1 = l\frac{dv}{dy},$$

in which l stands for the average vertical path of the irregularly moving particles, referred to as "mixing length."

We next come to a rather important point in the new turbulence theory which does not seem to have been sufficiently stressed in the works which tend to popularise its principle; namely, the existence of a "correlation" between the instantaneous horizontal and vertical departures from the mean velocity. In fact, the whole theory stands or falls with this basic postulate.

Consider two irregular lines, AB and CD

[19] "Elementary Mechanics of Fluids," by Hunter Rouse, 1946, page 211.

[20] "Proceedings," Am. Soc. Civ. Eng., April, 1947, page 470.

(see Fig. 13), which are supposed to represent two observed scalar values. In this case, these values are the horizontal and the vertical departures (v_1 and u_1) of the velocity.

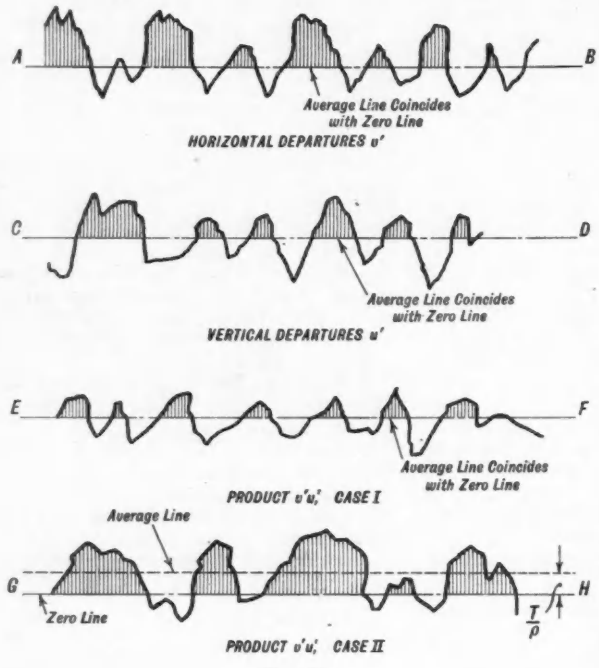


FIG. 13

Now prepare a third curve, which represents the instantaneous products of these two basic values. Two cases might then occur. If the basic values bear no relation to one another there is no reason for the positive products to be greater than the negative ones (or vice versa), so that over a sufficiently long period, the algebraic sum of the two products will tend to zero. This is the case shown by the curve *EF*. But suppose now that there is a tendency towards a coincidence of the two phenomena, viz., the upper line is more likely to be above the zero line when the same occurs with the second curve. The sum of the positive products will then be greater than the negative sum, so that the average line of the products curve will be above the datum, as shown by the *GH* curve in the same illustration. It can then be said that there exists a correlation between the values represented respectively by the two basic curves.

The existence of such a correlation between the v_1 and u_1 components of the velocity fluctuations (i.e., between the fluctuations in magnitude and in direction of the velocity vector) is a necessity, without which no tangential force (shearing stress) could have been transferred through a plane parallel to the main flow (except through laminar viscosity). The point can be made clearer if we consider the "constancy-of-mass"

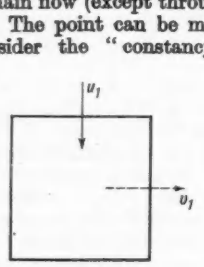


FIG. 14

principle as applied to the elementary volume shown in Fig. 14. In fact, a sudden increase of velocity represented by the fluctuation v_1 must of necessity be accompanied by a compensating flux u_1, so as to maintain constant the volume of the water contained in the elementary cube.[21]

The importance of the part played by this correlation in the structure of the new turbulence theory will be clear from the fact that the shear τ, which is the basic value in developing the "scala" curve, is equal to the product $v_1 \times u_1$, multiplied by the density ρ, thus :—

$$\tau = \rho v_1 u_1.$$

This equation is again a basically important element of the new theory. To demonstrate its validity consider two adjacent layers of water (see Fig. 16), *A* and *B*, the area of contact being *S*.[22]

The cross-current discharge, passing from one layer to another, will be the area *S* multiplied by the vertical component u_1 of the velocity and $\rho u_1 S$ will then be the mass of water exchanged between the layers per unit of time. To obtain the corresponding momentum the result is multiplied by v_1, which gives the momentum exchange (and therefore a tangential force)

$$F_t = \rho S u_1 v_1.$$

The unit stress is obtained by dividing this force by the area *S*

$$\tau = \frac{F_t}{S} = \rho u_1 v_1.$$

Reverting now to the equation for the shear τ, there can be substituted for v_1 its value $l\frac{dv}{dy}$ obtained in page 499. This will give

$$\tau = \rho u_1 l \frac{dv}{dy}.$$

Replacing τ and u_1 by their statistical averages

$$\bar{\tau} = \rho \sqrt{\overline{u_1^2}}\, l\, dV/dy$$

and, since

$$\eta = \rho \sqrt{\overline{u_1^2}}\, l,$$

$$\tau = \eta dv/dy.$$

This is the equation already used before, in developing the logarithmic curve.

In order to show that the concept of the "mixing length" is not an altogether abstract idea, but refers to a length of a finite size, a diagram is produced (see Fig. 15), giving the experimentally calculated mixing lengths for pipes, at various distances from the boundary (high and low Reynolds numbers).

A rather important problem in hydraulic engineering is to work out the average velocity in a vertical, as determined by the shape of the scala curve adopted. The still popular assumption that this average is at two-thirds depth from the surface must be relegated to the realm of historical archives, for it is obviously derived from the old-fashioned parabola. Using, therefore, the logarithmic law of velocity distribution, which is substantiated both by advanced

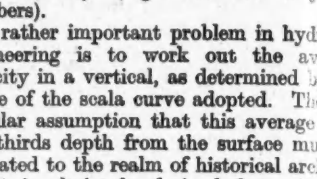


FIG. 16

theory and by statistical examination of reliable field data, there is obtained for the unit discharge (discharge per unit width of channel) the following :—

$$q = \int_{y=0}^{y=H} v\,dy = \sqrt{\tau_o/\rho} \times \int_{y=0}^{y=H} \left(2{\cdot}5 \log_e \frac{y}{K} + 8{\cdot}5\right) dy$$

$$= \sqrt{\tau_o/\rho}\, H\left(2{\cdot}5 \log_e \frac{H}{K} + 6\right)$$

in which *H* is the total depth of water.

The mean velocity is then equal to :—

$$v_m = \sqrt{\tau_o/\rho}\left(2{\cdot}5 \log_e \frac{H}{K} + 6\right)$$

$$= \sqrt{\tau_o/\rho} \times \left(5{\cdot}75 \log_{10} \frac{H}{K} + 6\right).$$

A rather important point of this analysis is arrived at by substracting from the velocity equation

$$\frac{v}{\sqrt{\tau_o/\rho}} = 5{\cdot}75 \log_{10} \frac{y}{K} + 8{\cdot}5$$

the formula for the mean velocity

$$\frac{v_m}{\sqrt{\tau_o/\rho}} = 5{\cdot}75 \log_{10} \frac{H}{K} + 6$$

There is thus obtained :—

$$\frac{v - v_m}{\sqrt{\tau_o/\rho}} = 5{\cdot}75 \log_{10} \frac{y}{H} + 2{\cdot}5$$

in which the roughness *K* does not appear at all. This means that, should the mean velocity be taken as basis for drawing the "scala" curve, the shape of that curve would depend on the "shear velocity," $\sqrt{\tau_o/\rho}$, only.

Further significant transformations of these equations are possible, through substituting for $\sqrt{\tau_o/\rho}$, the equivalent value

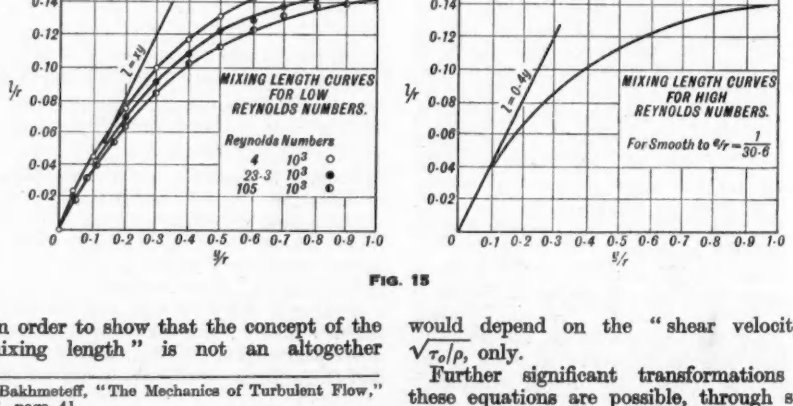


FIG. 15

[21] Bakhmeteff, "The Mechanics of Turbulent Flow," 1936, page 41.

[22] *Ibid*, page 39.

$v_m\sqrt{f/8}$, in which f is the so-called d'Arcy-Weisbach friction coefficient.

In concluding this very brief summary of the main points of "fluid mechanics," attention is called to the fact that while this relatively new science is essentially intended for general application to all cases of hydraulics, it is only natural that it should have started with the simplest case, namely, that of circular pipes; which also supplied the easiest field for experimental verification. The application of the new methods and equations to a different field, i.e., open-channel flow, is therefore subject to certain qualifying remarks, owing to its greater complexity referring, specifically, to the following points:—

(*a*) The existence of a free surface.
(*b*) Non-uniformity of the section.
(*c*) Secondary currents.
(*d*) Variable shear over boundary.
(*e*) Presence of bed load.
(*f*) Presence of suspended load.

Obviously, the "mixing length" cannot attain its maximum value at the free surface, as appears to be the case if we apply to open channels the equations of pipe flow. This, however, need not necessarily be a substantial objection, for in the case of pipe flow there is also a discontinuity of velocity distribution in the centre of the pipe, which, however, does not upset the validity of the equations. More serious matters are the cross currents created near the banks, which tend to depress the region of maximum velocity deeper below the surface. The effect of these secondary currents is, however, reduced with an increasing width-to-depth ratio, so that for a natural river or an important canal it is often of relatively little importance. The variable shear at different points of the perimeter is still another parameter of the flow, depending on the width-to-depth ratio, which is constant, and therefore numerically inoperative, in channels of semi-infinite width.

It follows from this argument that, in applying the methods of fluid mechanics (in their present stage of development) to open-channel problems, better results and a more precise picture of the phenomenon are likely to be obtained for wide natural rivers and large canals, rather than for small artificial channels.

(To be continued)

Present-Day Locomotive Working in Great Britain

PART I—THE WESTERN REGION "CASTLE" CLASS

By O. S. NOCK, B.Sc., A.M.I.C.E., M.I.Mech.E.

IN the long history of steam locomotive development in Great Britain one can single out a number of individual designs that have proved outstanding in one respect or another. Most of such selections belong to earlier days, as the achievements of notable locomotives can be seen more clearly, not only against their own contemporary background but in the light of subsequent history. In the last forty years many claims for high distinction have been made on behalf of the Churchward four-cylinder 4-6-0s of the Great Western Railway, and no less on behalf of their immediate development, the "Castle" class of 1923. The latter design indeed holds one record which, if it does not stand for all time, will certainly take many years to surpass: it is, that express passenger engines have been built to this same design, with no more than detail modifications, over a period of twenty-seven years. It seems significant of its success that this one design should have been perpetuated so long, particularly on a railway like the Great Western, whereon much store was set upon high thermal efficiency, apart from other facets of general engine performance.

Successive stages in development, from the Churchward "Stars" of 1906–7, to the Hawksworth variety of the "Castles" of 1946, are shown briefly in the accompanying Table I. Construction of the "5098" series has continued until the autumn of last year: the final engine of the series, No. 7037, was named "Swindon" by H.R.H. Princess Elizabeth on the occasion of her visit to Swindon works on November 15, 1950. In keeping with the longevity of the series as a whole, the performance of the "Castles" has been very fully documented. This documentation has not only taken the form of road tests with the dynamometer car; it includes the usual statistical records of mileage run, overall coal, water and oil consumption, and casualties and the scores of detailed logs of individual journeys compiled by students of locomotive running. Beyond this, with the aid of the Swindon stationary testing plant, the thermodynamic performance of the engines has been critically analysed in a wide variety of speed and loading conditions, and the results have been used as a basis of the point-to-point running times scheduled in regular service, these times having been arranged to conform with the most economical working of the locomotives.

When the Institution of Locomotive Engineers visited Swindon works on May 12, 1950, among the charts exhibited adjacent to the stationary testing plant were some relating to the coal consumption of the "Castle" class locomotives; and by the courtesy of the Railway Executive, Western Region, two of these charts are reproduced in Figs. 1 and 2, herewith. Apart from their value in the planning of express train schedules they are of great interest as showing the considerable variation in coal consumption per drawbar horsepower-hour that occurs with different conditions of steaming and speed. It is sometimes thought that measurement of coal consumption per i.h.p. or d.h.p. hour eliminates much of the variation in driving technique and reduces engine performance to a common yardstick by which direct comparison can reliably be made between one locomotive and another. This is not so, unless speeds on individual runs are kept the same at all points.

From the curves in Figs. 1 and 2, some tables have been prepared which show up the performance of the "Castle" class engines in a further interesting light. Referring first of all to running on level track, the speed for the most economical use of fuel in various loading conditions is indicated in the Table II.

TABLE II—*Performance on Level Track*

Load behind tender (tons)	Speed, m.p.h.	Coal per d.h.p. hour (pounds)	Coal per train mile (pounds)
254	71	3·5	25
326	64½	3·17	27½
399	60½	2·95	29½
472	58½	2·8	30½
544	55	2·7	32½

Coal consumption: 57 lb per square foot grate area per hour.

On a rising gradient of 1 in 200 the most economical speeds for the same range of train loading are generally below the normal requirements of traffic, viz:—

Load in tons	254	326	399	472	544
Speed, m.p.h.	41½	34	32	30	27½

But the results for faster climbing do not show coal consumption rates much in excess of the most economical figures for level road. These figures are set out in Table III.

TABLE III—*Performance on 1 in 200 rising gradient*

Load behind tender (tons)	Speed, m.p.h.	Coal per d.h.p. hour (pounds)	Coal per train mile
254	60	3·6	45
326	55	3·3	49
399	50	3·15	54
472	45	3·0	60
544	40	2·85	67½

Coal consumption: 86 lb per square foot of grate area per hour.

A further point is brought out from examination of the graphs in Figs. 1 and 2, namely, the less economical performance that can be realised in the working of relatively light trains. Table IV has been prepared, showing the coal consumption involved in the haulage of various loads at a uniform speed of 65 m.p.h. The rate per d.h.p. hour lessens from 3·6 lb to a little under 3 lb, this drop being due to the lessening proportion of engine

TABLE I.—*G.W.R. Four-Cylinder 4-6-0 Locomotives*

First engine No.	40 *	4001 *	4021 †	4041	4073	5098
Name...	"North Star"	"Dog Star"	"King Edward"	"Prince of Wales"	"Caerphilly Castle"	"Clifford Castle"
Year built	1906	1907	1909	1913	1923	1946
Cylinder dimensions, diameter by stroke (inches)	14½×26	14½×26	14½×26	15×26	16×26	16×26
Boiler:						
Heating surface (square feet)						
Tubes	1988·65	1988·65	1599·4	1686·6	1885·62	1799·5
Superheater	—	—	260·0	283·42	262·62	295·0
Firebox	154·26	154·26	155·0	154·78	163·76	163·5
Grate area (square feet) ...	27·07	27·07	27·07	27·07	30·28§	29·36
Boiler pressure (pounds per square inch)	225	225	225	225	225	225
Adhesion weight (tons)	39t. 12 cwt‡	55t. 8 cwt	55t. 8 cwt	55t. 8 cwt	58t. 17 cwt	58t. 17 cwt
Total engine (weight, tons) ...	74t. 10 cwt	75t. 12 cwt	75t. 12 cwt	75t. 12 cwt	79t. 17 cwt	79t. 17 cwt
Nominal tractive effort at 85 per cent boiler pressure (pounds)	25,085	25,085	25,085	27,800	31,625	31,625

* As originally built. † Not "King" class. ‡ 4–4–2 type originally. § Waterways altered slightly after first ten boilers were built, reducing the grate area to the present figure of 29·36 square feet.

and tender weight to the total moving load as the train weight increases.

TABLE IV—*Uniform Speed of 65 m.p.h.*

Load behind tender (tons)	Coal per d.h.p. hour (lb)	Coal per square foot grate area per hour (lb)
254	3·6	49·5
326	3·2	49·5
399	3·0	56
472	2·95	67
544	2·95	77

Some examples of past and present scheduling over the nearly level stretches of the Paddington-Bristol main line will indicate how the performance characteristics of the "Castle" class engines were and are applied in practice. The following are flying averages, not start-to-stop bookings, between Southall and Didcot, 44 miles.

Train	Load behind tender (tons)	Average speed, (m.p.h.)
"Bristolian"* ...	235	74·3
11.15 a.m.* ...	350	65·2
6.30 p.m.†	455	60·0

* Pre-war. † Present timing

The author's personal experience on the footplate of these engines, amounting to nearly 1900 miles of travel, has shown methods of actual handling on the part of the drivers that approximate more nearly to complete uniformity than anything he has seen elsewhere. Without exception the running cut-offs on level road have lain between 15 and 20 per cent, with a generous opening of the main regulator valve. There has never been a single instance of "driving on the throttle"—fixing the cut-off at 25 or 30 per cent, or so, and leaving it unchanged up hill and down dale. Such variations as have been noted, sometimes on the same engine in the course of a single run, as on the 10.35 a.m. from Wolverhampton to the West of England, on which crews are changed at both Bristol and Exeter, have not extended beyond one man using 20 per cent cut-off and regulator about three-quarters open, and his successor using full regulator and 17 to 18 per cent cut-off. The same uniformity has applied to the firing: a little and often, maintaining the well-known Great Western hay-cock formation, even on some recent occasions when fuel other than soft Welsh coals were being fired.

The engines selected for footplate observations were usually in very good condition, and their performance displayed the capacity of the "Castle" at high level if not necessarily at optimum value. But in addition to these footplate runs the author has made, since October, 1946, a large number of journeys as a passenger on Great Western, and more recently Western Region trains, with the results summarised in Tables V and VI. On each journey a log was compiled with sufficient detail in the way of passing times and speeds to enable the cost in running time of signal checks, engineering slacks and other out-of-course delays, to be accurately assessed, and the gain or loss on scheduled time attributable to the locomotive to be calculated. Two tables have been prepared, one relating to journeys including non-stop runs of 70 miles or more, and the second covering journeys on which the longest start-to-stop runs were less than 70 miles. The summary tables include all journeys as a passenger made by the author between October 1, 1946 and September 1, 1950, on which engines of the "Castle" class were used, excepting a very few on which a second engine was attached—not on account of overloading but to facilitate a return engine working. It should be emphasised that these runs cover regular travel during the exceptional winter weather of February and March, 1947.

FIG 3—WESTERN REGION "CASTLE" CLASS LOCOMOTIVE "EARL OF PLYMOUTH"

TABLE V—*"Castle" Class Locomotives. Summary of Runs with 70 Miles or More Non-Stop. October, 1946, to September, 1950*

Total miles run	8035 miles
Booked running time	8873 min
Average speed, m.p.h.	54·4 m.p.h.
Total number of runs	83
Total number of runs when time booked against engine	9
Total time lost in above 9 runs	48 min
Total time gained by engine in remaining 76 runs	342 min
Net aggregate running time, all runs ...	8579 min
Net average speed	56·2 m.p.h.
Average load, gross behind tender	420 tons
Number of different engines used	48

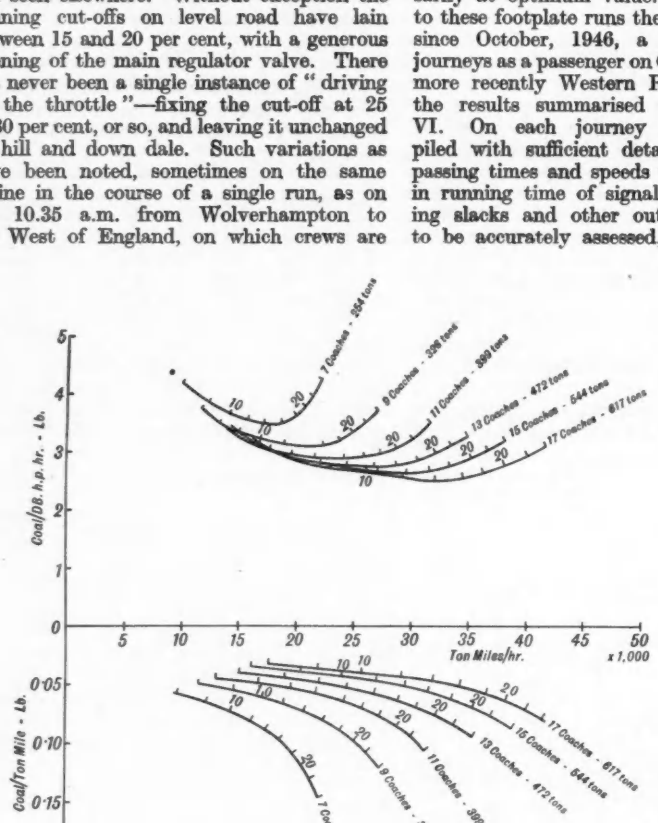
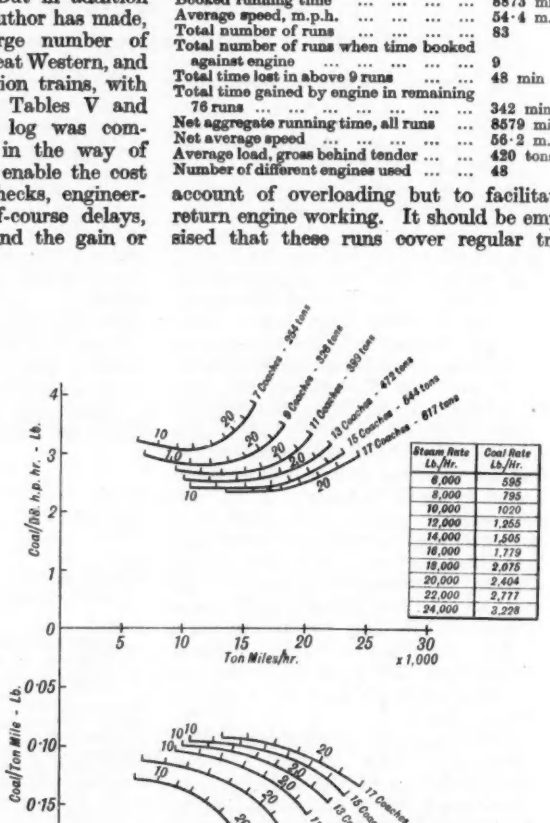

Coal/D.B. h.p. hr. - Lb.
Ton Miles/hr. x 1,000
Coal/Ton Mile - Lb.
7 Coaches - 254 tons
9 Coaches - 326 tons
11 Coaches - 399 tons
13 Coaches - 472 tons
15 Coaches - 544 tons
17 Coaches - 617 tons

FIG. 1—PERFORMANCE ON LEVEL TRACK


Coal/D.B. h.p. hr. - Lb.
Ton Miles/hr. x 1,000
Coal/Ton Mile - Lb.
7 Coaches - 254 tons
9 Coaches - 326 tons
11 Coaches - 399 tons
13 Coaches - 472 tons
15 Coaches - 544 tons
17 Coaches - 617 tons

Steam Rate Lb./Hr.	Coal Rate Lb./Hr.
6,000	595
8,000	795
10,000	1020
12,000	1,255
14,000	1,505
16,000	1,779
18,000	2,075
20,000	2,404
22,000	2,777
24,000	3,228

FIG. 2—PERFORMANCE ON RISING 1 IN 200 GRADIENT

During the period extending from October, 1946, to April, 1947, out of twenty-five runs non-stop over 70 miles or more there was time to be booked against the engine

on only five occasions, and on two of these trips high adverse winds were partly to blame. Except on one single occasion when bad steaming caused a loss of 15 min to engine on the 107-mile Paddington-Bath run of the 1.15 p.m. down (booked speed 56·2 m.p.h.), there has been no case

TABLE VI—"*Castle*" *Class Locomotives. Summary of Runs, With no Non-Stop Run Exceeding 70 Miles. October, 1946, to September, 1950.*

Total distance run	4943 miles
Booked running time	5986 min
Average speed	49·5 m.p.h.
Total number of runs	55
Total number on which time booked against engine	12
Time lost on above 12 runs*	46 min
Total time gained by engine in remaining 43 runs	159 min
Net aggregate running time, all runs ...	5873 min
Net average speed	50·4 m.p.h.
Average load, gross, behind tender ...	447 tons
Number of different engines used	34

*Includes one very bad run with engine No. 100 (when oil-fired), on which 21 min were lost.

of a loss to engine of more than 7 min throughout the four-year period covered by the tables. The average speed booked is relatively high and loads range up to a maximum of 495 tons. While it is true that the majority of these runs have been noted between Bristol, Bath and Paddington over a comparatively level road, such a course is likely to prove more trying in adverse conditions than a sharply undulating one. Westbound from Paddington there can be no "let-up" in the first 80 miles, and against the combination of a slight, though continuous rising gradient and the prevailing wind, it needs first-class work to pass Swindon (77·3 miles) in the 82 to 83 min regularly made with 450-ton loads on a train like the 6.30 p.m. down.

The table of results from "stopping" trains include some hard turns like the 1.18 p.m. down of the fuel emergency period in the late spring of 1947, when the 1.15 p.m. Bath non-stop was suspended and the luncheon-car train normally working the latter service operated the 1.18 p.m. This train had an allowance of 113 min for the 77·3 miles from Paddington to Swindon, with stops at Reading, Didcot, Wantage Road and Challow, totalling 13 min between them. This needed some smart running with the normal six or seven-coach formation; but it became a stiff proposition with a heavy restaurant-car train, sometimes totalling 420 or 430 tons. Yet in nine journeys with this train the odd minutes to be booked against engine on some trips were balanced by equal amounts gained on others.

In the Tables V and VI allowance has been made for out-of-course delays, so that they represent an analysis of engine performance rather than of ultimate service to the public. While it will be agreed that service to the public is dependent upon many factors beside that of locomotive capacity, one further summary table, from the author's travelling experience, is of interest as showing the punctuality record of one particular train, the 4.15 p.m. from Paddington to Bristol. On an average of four days in every week this train is joined at Chippenham, to travel to Bath and since April, 1950, a note has been kept of the arrival time at Chippenham. The time allowance is 122 min for the 94 miles from Paddington, including two stops, at Reading and Swindon, totalling 13 min between them. This leaves a running average of 51·7 m.p.h. The usual load is one of eleven coaches, 370 tons tare and 390 to 400 tons gross behind the tender. The following is the arrival time record since April 12, 1950, when note taking in this respect started, until October 20, 1950:—

Number of runs with "Castle" class engines ...	60
Number of runs punctual or before time	53
Number of different engines employed	16

Of the seven occasions on which the train drew into Chippenham behind time, one, 14 min late, was during the freak snowy weather of April, 1950; on a second, when the train was 19 min late, due to a signal failure, the departure from Swindon had been on time. On the remaining five occasions, when arrivals were 2, 9, 5, 5 and 4 min late, respectively, the locomotives concerned were worked so vigorously between Chippenham and Bath as to suggest that the lateness was no fault of engine or driver.

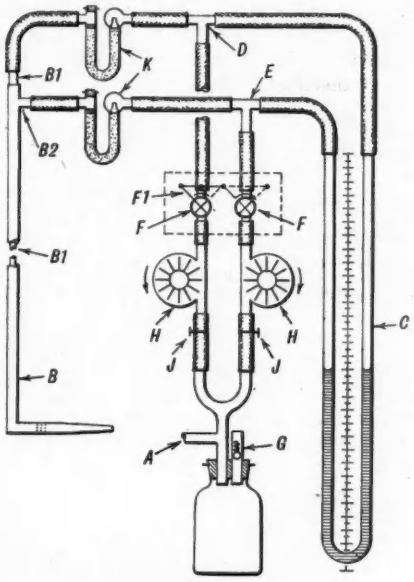
The author would submit that this punctuality, taken with the summarised results of travelling extensively as a passenger, constitutes an exceedingly fine record to the credit of the "Castle" class locomotives. The planning of train schedules to utilise engine power at its most economical level is an ideal that has been put into operation for many years on the former Great Western Railway. Its effectiveness in day-to-day train working over a considerable period is brought out in the general mastery over loads revealed by the Tables V and VI, and in the standardised methods of driving and firing noted on all footplate journeys. The question of making an effort above "standard" when a train is running behind time raises points of footplate psychology that are as old as railways are themselves. Some drivers will never make up time, no matter how much their engine is master of the job; other men will make it almost a point of honour to do so. Detailed examination of the runs summarised in Table V shows that about 70 per cent of the enginemen whose work has been so recorded lie between these two extremes, and that the majority of this 70 per cent will rise to the occasion in greater or lesser degree in cases of late running, depending largely upon footplate conditions. One gains the general impression that the number of exceptionally keen and competent crews is no less than it was twenty-five years ago; conditions to-day however, do not often favour the making of spectacular runs, though a high percentage of "Castle" class engines could do so if the need arose.

(To be concluded)

The Use of a Pitot Tube in a Dust-Laden Gas Stream

By T. H. HUGHES and C. P. SAYLES, M.A. (Cantab.)

WHEN sampling the dust carried by a gas stream, it is essential that the velocity in the sampling tube shall not vary, beyond certain limits[1], from the velocity of the main stream at the sampling point. Since the velocity is rarely uniform over a cross section of a gas stream in a pipe or duct, it is necessary to determine the velocity at each selected sampling point in the cross section. When the velocities are sufficiently high this may be done by means of a pitot tube.[2]



A—Purging air inlet.
B—Pitot tube.
B1—Pitot tube, total head line.
B2—Pitot tube, static head line.
C—"U" gauge.
D and *E*—"T" connections.
F—Change-over cocks.
F1—Operating linkage.
G—Relief valve.
H—Anemometers.
J—Constricting clips.
K—Filters.

FIG. 1—DIAGRAMMATIC LAYOUT OF PITOT TUBE PURGING APPARATUS

When a pitot tube is used to explore a stream of flue gas it is not likely to become choked with dust particles since the dust concentration normally does not exceed about 12 grains per cubic foot[3], but with heavily laden gases, such as the primary-air supply to a pulverised-fuel burner, where the dust concentration may be as high as 250 grains per cubic foot, a method of preventing the dust from blocking the pitot tube has to be provided. The apparatus shown in Figs. 1 and 2 was developed and used satisfactorily for this purpose by the staff of the Fuel Research Station during the course of a series of trials on a power-station pulveriser,

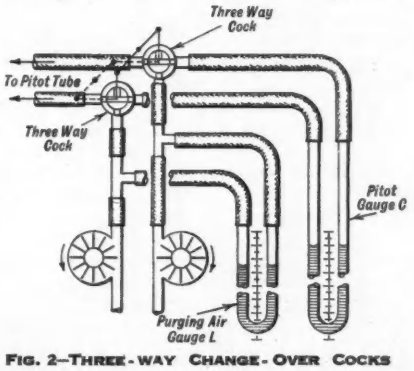


FIG. 2—THREE-WAY CHANGE-OVER COCKS

when it became necessary to explore the distribution of velocities in a primary-air pipe-line.

DESCRIPTION OF APPARATUS

As will be seen from Figs. 1 and 2, the apparatus is designed so that air is forced outwards through the pitot tube into the main stream, except at times when velocity measurements are being made.

The air, which may be supplied from a small compressor or other suitable source, is connected to the lines joining the pitot tube *B*, and the "U" gauge *C*, at the points *D* and *E* (Fig. 1). While a reading is being taken the purging system is isolated from the pitot tube and "U" gauge by means of two linked change-over cocks *F*, which are operated simultaneously. When not required, the purging air is allowed to escape through the relief valve *G*, the load on which is adjusted so that the "U" gauge will not "blow" should one of the pitot-tube lines become blocked. As an indication that the total and the static-pressure lines of the pitot tube are clear immediately before a reading is taken, an anemometer *H* is inserted in each line.

Constructional details of the relief valve and the anemometers used in the prototype apparatus are given in Figs. 3 and 4.

Method of Carrying out a Velocity Exploration

(a) *Setting up and Testing the Apparatus.*—The apparatus is set up level at a convenient position near the sampling points and connected to the supply of air for purging.

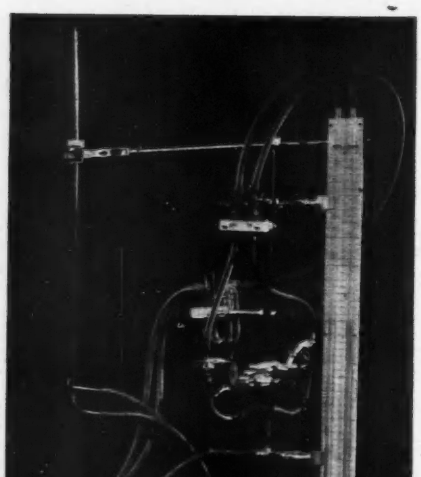


Fig. 3—General Arrangement of the Prototype Apparatus

The cocks are then tested for leaks by immersing the end of the pitot tube in liquid, and turning them alternately "on" and "off." There should be no bubbles when the cocks are in the "off" position. If the pitot tube is immersed in water it should be allowed sufficient time to dry with the purging air "on" before inserting it into the dust stream. By using spirit, the time allowed for drying can be appreciably reduced. The test for leaks is also carried out at convenient intervals during a series of velocity measurements.

Experience has shown that the total-head tube is more likely to become blocked than the static-head tube during a velocity exploration and it therefore requires a greater proportion of the air to keep it clear. This may be arranged by adjusting the constricting clips J (Fig. 1). When relatively high velocities are being measured, using a "U" gauge, a pressure difference of about 4in w.g. has been found suitable. With smaller velocities, measured by means of an inclined gauge, the pressure difference in the two limbs may be correspondingly reduced.

(b) *Velocity Exploration.*—Two operators are required to carry out a velocity exploration. One sets the pitot tube in position and the other controls the purging apparatus and records readings of velocity head.

The general procedure is as follows. With the purging air "on," the pitot tube is inserted into the pipe at the desired sampling point. The purging system is then isolated from the pitot tube and gauge by the change-over cocks and a reading of velocity head recorded. The cocks are now

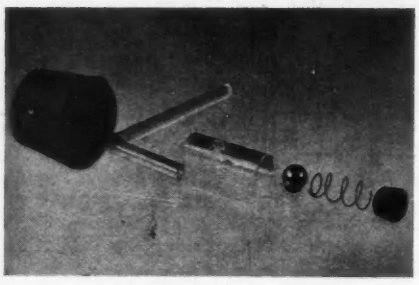


Fig. 4—Exploded View of Relief Valve

returned to the "on" position, when the free passage of air through the total and static-pressure lines will be indicated by the rotation of the anemometer vanes. Should the purging air fail to clear the lines, clearance can usually be effected by a gentle tap on the side of the pitot tube.

It has been found that, for high velocities and heavy dust concentrations, blockage of the apertures in the pitot tube is indicated by further movement of the liquid in the "U" gauge soon after it has become steady at the reading corresponding to the velocity. It is therefore necessary under these conditions to take readings immediately the liquid in the "U" gauge makes a definite pause. In extreme cases, the pause may be of brief duration and this is a possible source of error. To reduce the risk of error, a series of observations is made at each sampling point, the number in each series depending upon the velocity and concentration of the dust and upon the stability of plant conditions.

During the trials on a power-station pulveriser with a heavy concentration of airborne fuel, ten readings were taken at each sampling point (Table I). This process might appear laborious but in practice the ten readings took a total time of only 2 to 3 minutes. Subsequently the time taken for the liquid in the "U" gauge to come to rest between successive readings was practically eliminated and the total time reduced considerably by replacing the two-way cocks *F*, shown in Fig. 1, by the three-way cocks shown in Fig. 2. This arrangement, however, has been tested only under laboratory conditions.

Table II shows the mean of ten readings

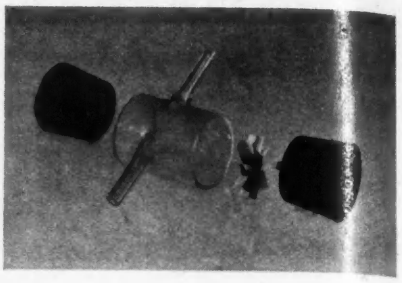


Fig. 5—Exploded View of Anemometer Indicators

recorded at points *A* to *K*, Fig. 6, for repeat tests at high and low rates of air flow. In each case the second test was made after an interval of time, during which the plant had operated under different conditions. The repeat tests thus include any errors, which arise from adjustment of the plant to the original operating conditions.

It will be observed that although the extreme variation of velocity in Table I

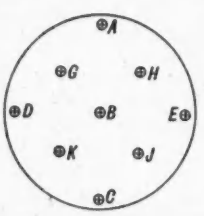


Fig. 6—Positions of Sampling Points in a Primary Air Pipe (11⅝in I.D.)

is of the order of 11 per cent the average variation of the mean velocities derived from the figures given in Table II is of the order of 4 per cent at a high rate of flow and 2 per cent at a low rate, both figures being no greater than the known variation in the total flow. It should be mentioned that the recorded variations of the total flow did not necessarily synchronise with the velocity measurements referred to above.

Table I—*Variation in Successive Readings at One Point*

Reading No.	1	2	3	4	5	6	7	8	9	10
Velocity head, in w.g.	5·0	4·4	5·4	4·9	4·5	5·0	4·7	4·4	4·9	4·3
Velocity, feet per second	135	127	140	134	128	135	131	127	134	125

Table II—*Variation in Mean Velocity Head*

Conditions		Mean Velocity head, in w.g.								
		A	B	C	D	E	G	H	J	K
High air rate	Test No. 1	1·2	2·8	3·9	3·2	2·0	2·3	0·5	4·8	3·1
	Test No. 2	1·1	2·7	4·2	2·8	1·9	2·4	0·7	4·7	3·1
Low air rate	Test No. 1	1·2	1·5	2·1	1·1	1·1	1·7	0·7	2·0	1·1
	Test No. 2	1·1	1·4	2·2	1·1	1·0	1·7	0·7	2·0	1·2

Conclusions

From the typical observations shown in Tables I and II it would appear that by using the purging device it is possible to overcome the risk of blocking the apertures of the pitot tube when measuring the velocity of an air stream carrying a high concentration of dust, without affecting the accuracy of measurement. Observations

made during a long series of tests show that, even in its prototype form, the device is practicable and easy to operate.

ACKNOWLEDGMENT

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REFERENCES

[1] B.S. 893 : 1940. Method of Testing Dust Extraction Plant and the Emission of Solids from Chimneys of Electric Power Stations.

[2] B.S. 1042 : 1943. British Standard Code for Flow Measurement.

[3] Wagner, H. W. Electrostatic Precipitators for Central Power Stations. Conference on Pulverised Fuel (Institute of Fuel), 1947, [Vol. I], papers presented, page 91.

The Physical Society's Exhibition

No. III—(*Continued from page 475, April 13th*)

IN this article we conclude our review of some of the exhibits seen at the Physical Society's Exhibition, which was held in London from April 6th to 11th.

BAIRD AND TATLOCK, LTD.

The need for variable speed operation of small electric motors in laboratories led to the development of an electronic speed control unit, which was demonstrated by the maker, Baird and Tatlock, Ltd., 14–17, St. Cross Street, London, E.C.1.

Although a.c. series wound and repulsion induction motors are generally satisfactory for constant load drives, speed control presents difficulties, since any method of varying the terminal voltage involves a serious drop in torque as the voltage and speed are reduced. The Baird and Tatlock speed control unit allows small shunt wound d.c. motors to be operated over a wide speed range when connected to ordinary single-phase a.c. mains. Conversion of the a.c. supply into direct current for the armature-field of the motor is effected by thyratrons operating as grid controlled rectifiers. Speed variation is achieved by the use of phase-shift networks in the grid circuits of the thyratrons; a small potentiometer serves to control the conducting portion of each half-cycle and thus to control the voltage applied to the motor. No loss of torque is involved, the torque remaining almost constant from standstill up to the rated speed, by varying the armature current with constant maximum field. By keeping the armature current constant at its maximum value and reducing the field the speed range can be further extended to about twice the rated speed, with a constant horsepower characteristic. At any given potentiometer setting the speed is held within close limits between no-load and full load. The control unit allows for reversing the direction of rotation with neutral brush setting. A dynamic braking resistance is included and it can be automatically connected when the motor is switched off. Any form of shunt wound motor up to $^1/_{20}$ h.p. can be controlled by the equipment described.

E. K. COLE, LTD.

Among the new exhibits shown by the electronics division of E. K. Cole, Ltd., 5, Vigo Street, London, W.1, was a portable instrument for detecting the presence of radioactive ores. The Portable Radioactive Ore Detector (or "Prod") incorporates a Geiger Muller tube, whereby the presence of radioactive material is indicated by an increase, above the normal background, in the rate of the voltage pulses, each of which is produced by a single photon, originating from the material. In this instrument the measurement is made by listening in suitable headphones to the audible "clicks" caused by each pulse, and by counting the number of "clicks" per unit time.

As illustrated in Fig. 13, the "Prod" is a simple instrument, in the form of a rod, which can be slung from the body or carried by hand and used as a probe, its weight being 3¼ lb, complete with its self-contained dry battery. The normal life of the battery, in temperate climates, is given as six to nine months, while the life of the halogen-quenched Geiger Muller tube is independent of the amount of use to which the instrument is put. There are no controls, the detector being permanently switched on and ready for use.

Another interesting equipment shown for the first time is the aerial polar diagram measuring equipment, which is intended for making accurate and automatic records of the polar diagrams of centimetric antennæ. For this purpose the antenna is mounted on the roof of a rotatable trailer and is "illuminated" by a fixed transmitter, while the amplitude of the received signal is continuously plotted against the angular rotation of the trailer and antenna. In the form exhibited the equipment covers a frequency range of 8500 to 9500 Mc/s, but any convenient range can be covered by appropriate substitution of two units.

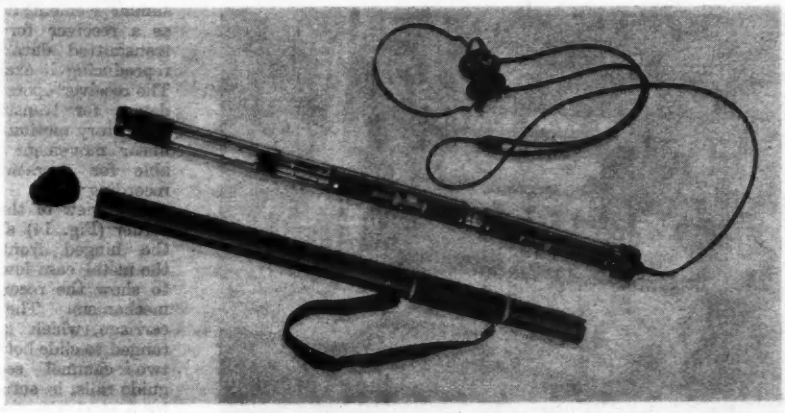


FIG. 13—PORTABLE RADIOACTIVE ORE DETECTOR—E. K. COLE

Apart from the transmitter unit, all the equipment is mounted in the trailer and remote controls are provided for transmitter frequency and polarisation. The received continuous wave signal is mixed with a modulated local oscillator signal and the resultant i.f. output is combined with an anti-phase modulated i.f. signal, derived from a 45 Mc/s oscillator and servo-driven piston attenuator. The combined signals are fed through a seven-stage, low-noise i.f. amplifier to a balanced modulator and the resultant error signal is applied to a servo-amplifier.

The amplified output drives a servo-motor, which operates the piston attenuator in the direction required to reduce the difference between the received signal and the reference signal. A pen carried by the piston drive mechanism records the amplitude of the received signal in terms of the attenuation law of the standard piston.

When operating in static conditions the total plotting error inherent in piston lag and the comparison system is less than 0·1db, but any rapid changes in the input signal will cause a velocity lag because of the inertia of the servo-system. To control this lag there is an "error meter" mounted above the manual rotation control and the operator receives a warning when the rotational speed becomes excessive. Plotting can be done either on Cartesian or polar co-ordinate graphs paper. In each case the amplitude scale is 10db per inch, with a maximum traverse of 65db, and the Cartesian co-ordinate paper can be run at rates corresponding to 2 deg. or 5 deg. per inch. Because the plotting is essentially self-calibrating there is little need for test gear with this equipment. To facilitate initial setting-up and routine checking, however, a small monitor oscilloscope is provided.

NATIONAL PHYSICAL LABORATORY

Exhibits representing research work on electricity, engineering, light, metrology and electronics were shown by the National Physical Laboratory on a part of the stand occupied by the Department of Scientific and Industrial Research.

The metrology division demonstrated a method whereby the determination of the errors of precision watches can be made independent of the human element.

Precision rating of watches requires the measurement of errors to an accuracy that is higher than the consistency of watch performance, which may be as good as 0·05 second per day. Any methods of measurement involving human errors are clearly inappropriate to determinations of such a precise order.

The method demonstrated by the N.P.L. uses a photoelectric link and is automatic. A small portion of the seconds dial is projected optically on to a screen in such a way that each forward movement of the image of the seconds hand occupies between 0·5cm and 1cm. When the image of the hand reaches a slit in the projection screen the light passing through it, on to a photocell, is reduced. The resulting signal from the photocell is amplified and passed to a decimal counter chronometer, which registers numerically the error of the watch with reference to a standard clock. The high amplification required is obtained by a light source producing 100 flashes per second and an a.c. amplifier. Using this method of measurement, the N.P.L. has obtained an accuracy of within ±0·005 second.

Another demonstration was concerned with the cathodic sputtering of non-metallic films and with some of the problems encountered in this process. For example, although cathodic sputtering by means of a high-voltage discharge in a gas such as argon has long been known as a means of depositing metal films, some attempts at metal deposition have been unsuccessful. It is pointed out, however, that failure to obtain a metallic film does not always imply failure to disperse the cathode material. Indeed, under certain conditions, the more reactive metals combine easily with gases or vapours present in the sputtering chamber and the resulting compound, instead of the metal, is deposited. Films such as these are usually much more transparent than the metal and their presence may be overlooked.

For example, oxide films of metals like cadmium or zinc can be produced by sputtering in oxygen. Since the presence of argon generally encourages a high rate of sputtering,

the oxygen or other gas that is to form the acid radical is conveniently introduced in an atmosphere of argon. It has been found that, in compounds like cadmium oxide, which are semi-conductors, the electrical conductivity of the film can be controlled by controlling the supply of the reactive gas, which is present as an impurity in the argon. Good uniformity, with close control of the thickness of non-metallic films can be achieved by this method.

Some of the interesting electrical and optical properties of these non-metallic films were demonstrated. For instance, simple films of lead oxide on glass may reflect as much as 50 per cent of the incident light, the absorption being low. Cadmium oxide films, having electrical conductivity at least as high as graphite, can, it is stated, be deposited—a fact which is of some significance in relation to the manufacture of the modern selenium rectifier photocell.

Muirhead and Co., Ltd.

Prominent among the exhibits shown by Muirhead and Co., Ltd., Beckenham, Kent, was the Muirhead-Pametrada wave analyser (type D-489.C), which is intended primarily for the analysis of complex vibration waveforms, such as those associated with ship's turbines and propeller shafts. It is, however, equally suitable for the measurement of audio and power frequency waveforms up to 21 kc/s.

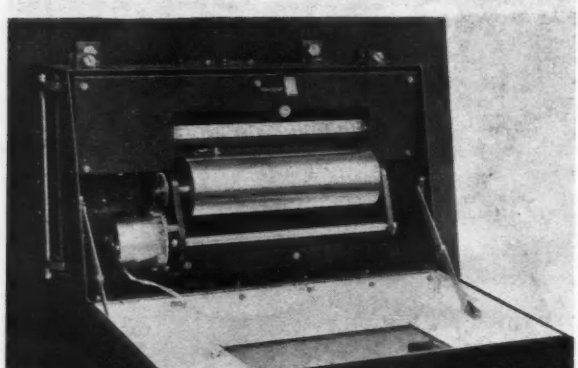


Fig. 14—Magslip Recorder—Muirhead

Unlike the heterodyne class of analyser, which produces an output frequency that is substantially independent of the frequency under test, the Muirhead-Pametrada analyser acts as a tunable filter and supplies the output meter with a signal of the same frequency as that of the selected component. When making noise measurements on vibrating machinery this selective output can be applied to an oscillograph and compared with the speed of the various rotating shafts. The circuit has a variable bandwidth characteristic which is very important when measurements have to be made of vibrations of fluctuating frequency. Various values of selectivity are available and the response near the peak of the curve is of constant selectivity—that is, the off peak response is proportional to the percentage mistuning. The accuracy of calibration is specified as $\pm 0{\cdot}5$ per cent at all frequencies, the response level being ± 2db over the whole range.

The analyser uses negative feedback, with resistance-capacitance tuning. Two selective amplifier units, connected in cascade, are embodied in the circuit. Tuning is done by simultaneous variation of two resistors in the arms of the Wien bridges, which provide the negative feedback circuit in each amplifier. A seventy-two stud rotary switch gives a tuning control that is variable in 1 c/s steps and there is a fine control, giving intermediate readings over a range of 2 c/s. A three-range switch and multiplier give a total coverage of the range from 19 to 21 kc/s.

Among the other controls are a three-position bandwidth control, a three-position selectivity control and an input attenuator. The output meter, which is calibrated in volts and decibels, is mounted at the top of the panel. At the bottom of the panel are terminals and jacks for taking the output to cathode-ray oscillographs and headphones respectively.

The wave analyser is energised from a separate supply unit, which operates from single-phase, 200–250V, 50 c/s mains. A multiway lead takes the various power supplies from the supply unit to the analyser. There is a meter on the supply unit to monitor the various h.t. voltages and the heater current—the heaters being series-fed with direct current to eliminate mains frequency interference. A 50 c/s calibrating voltage is brought out to a jack on the panel; this calibrating voltage can be checked on the supply unit meter and adjusted if necessary.

Another equipment demonstrated on this stand was an instrument in which the Magslip system of data transmission has been developed, in a form suitable for the remote indication and recording of water levels and other variables. In this recorder the initiating movement is made to turn the rotor of a 2in Magslip synchronous link element, which acts as a data transmitter. In the recorder at the remote point there is a similar element, acting as a receiver for the transmitted data and reproducing it exactly. The receiver operates a device for translating the rotary motion into linear movement suitable for operating a recording pen.

Our view of the recorder (Fig. 14) shows the hinged front of the metal case lowered to show the recording mechanism. The pen carriage, which is arranged to slide between two channel section guide rails, is actuated by a steel wire passing over a pulley, which is rotated by the receiver. A heart-shaped cam, with a spring-loaded follower, serves as a flexible coupling between the Magslip receiver and the driving pulley and prevents the receiver being overloaded if the transmitter is moved beyond the limit of travel of the pen; it also allows the pen to be moved independently of the receiver and ensures that the pen, when released, will take up its correct position.

On the pen carriage there is a pointer, which traverses a suitably engraved scale, whereby an instantaneous reading is always available. As can be seen from Fig. 14, the chart drum is driven by an a.c. synchronous motor through reduction gearing at a speed which allows for a continuous twenty-four-hour record. The Magslip elements are standard elements, which operate from a 50V, 50 c/s supply. The chart drum is $8\frac{1}{4}$in long by $2\frac{5}{16}$in in diameter, and the case measures 16in by $8\frac{1}{4}$in by $9\frac{3}{8}$in high, the dimensions of the rectangular window in the front cover being sufficient to give full view of the drum and the engraved scale.

Mullard Radio Valve Company, Ltd.

A simple electronic instrument for the precise control of temperature was among the apparatus shown by the Mullard Radio Valve Company, Ltd., Century House, Shaftesbury Avenue, W.C.2. In this temperature controller a temperature-sensitive element is held in intimate thermal contact with the apparatus that is to be controlled. The resistance of the element changes with temperature and thereby unbalances a bridge network of which it forms one arm. The bridge circuit is supplied at 50 c/s and the phase of the out-of-balance voltage changes sharply on passing through the balance point, that is, as the temperature goes through the critical value. After being amplified the output signal from the bridge is taken to a phase-sensitive network, which operates a relay to control the heating element. The instrument scale is stated to be accurate to $\pm 0{\cdot}5$ deg. Cent. but, after the instrument has been set up, its indications are consistent within $0{\cdot}02$ deg. Cent.

A precision variable capacitor, designed to combine good performance with compactness and ease of production, was also shown (Fig. 15). Points of interest about this design include the use of highly finished ball races, polytetrafluorethylene insulation, bimetallic temperature compensation and the use of specially prepared brass vanes in a stress relieved housing.

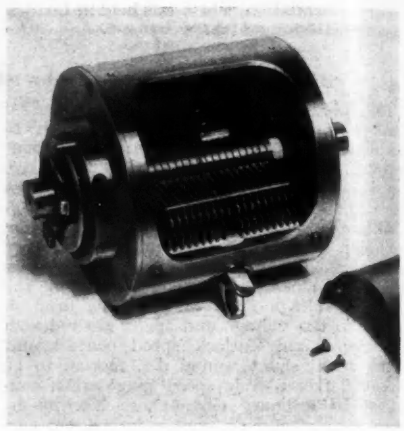


Fig. 15—Precision Variable Capacitor—Mullard

The capacitor plates are shaped to give a straight line frequency characteristic to within $\pm 0{\cdot}1$ per cent and batches of capacitors are matched to within $\pm 0{\cdot}03$ per cent. Its self-inductance is $0{\cdot}015\mu$H and its capacitance swing is 320pF. Two and three-gang versions of this design of capacitor, having a somewhat lower accuracy, are being produced.

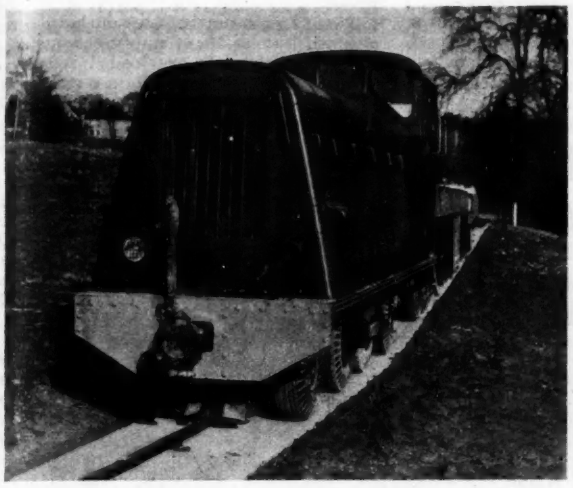
Barr and Stroud, Ltd.

A radar navigational chart comparison unit, developed in collaboration with the Admiralty, was shown by Barr and Stroud, Ltd., Anniesland, Glasgow, W.3.

The equipment is intended to supplement radar for navigational purposes, by enhancing the accuracy of normal radar techniques. It is particularly useful in conditions of poor visibility. With the equipment exhibited, images of the navigational chart and the radar plan position indicator (P.P.I.) can be superimposed and viewed through an eyepiece. It therefore relates the ship's position with the instantaneous picture provided by the radar and allows the coast line and marks to be identified on the chart. A variable magnification optical system allows the chart image to be magnified to suit the scale of the P.P.I. A special circular graded filter is fitted, to produce the correct ratio of illumination between the chart and the P.P.I. and the filter can be rapidly adjusted to give any required transmission factor between transparency and opacity. It is a characteristic of the filter that the light loss is negligible at the bright portion. Another detail that improves light transmission is the use of a neutral beam-splitting prism, which combines the beams reaching the eyepiece from the two optical fields. The improvement is stated to be 30 per cent compared with the usual semi-silvered surface. The comparison unit measures approximately 28in by 28in by 11in; it is light and can be mounted on the deckhead or a bulkhead on the trunnions provided.

The "Uniline" Transport System

A MAJOR problem encountered in the recovery of raw materials from undeveloped areas is that of providing a simple, yet efficient, means of transport where a road or rail system would not initially be economic. Following careful investigation of this particular problem, J. Brockhouse and Co., Ltd., of West Bromwich, has developed an interesting transport system which is based upon a method first evolved a number of years ago and applied in an experimental project in India. The system is not in any way intended to compete with existing rail or road systems, but is designed to supplement those already in existence and also to provide the necessary link in areas where the two known systems are not suitable. In the "Uniline" system, as it is known, many new features both in design and operation have been introduced by Mr. R. E. Hagley, the executive engineer of J. Brockhouse and Co., Ltd., who has been primarily responsible for its development.



"UNILINE" TRACK AND LOCOMOTIVE

This system of transport consists essentially of a prepared track or road down the middle of which is laid a single rail. Load-carrying vehicles hauled by a prime mover along the track are guided by vertical rollers, which are suspended from their axles and register on each side of the head of the track rail. Both the prime mover and its vehicles are fitted with heavy pneumatic tyres. Guide rollers are not fitted to all axles on the vehicles, but only to those at the leading and trailing ends of each unit. With this system, therefore, the main principle of the orthodox railway in confining the vehicles to run on a defined track is utilised, but only one section of light rail is used.

An important fundamental feature of the "Uniline" system is the use of rubber tyres on the vehicles, which makes it possible to utilise the available tractive effort at the driving wheels with considerably reduced static axle loads, since the coefficient of friction, with wheels running on a prepared track, is about four times greater than that of tyre rails in normal railway practice. This feature not only allows a considerable reduction in the static weight of the prime movers, but is of great importance in braking a train on steep down grades because of the greater retarding force which can be applied without the wheels slipping.

Experiments have shown that whilst the rolling resistance of vehicles in the "Uniline" system is somewhat higher than that of light railway vehicles, the curve resistance is very much lower; in fact, it is claimed to be no higher than that obtained on the straight.

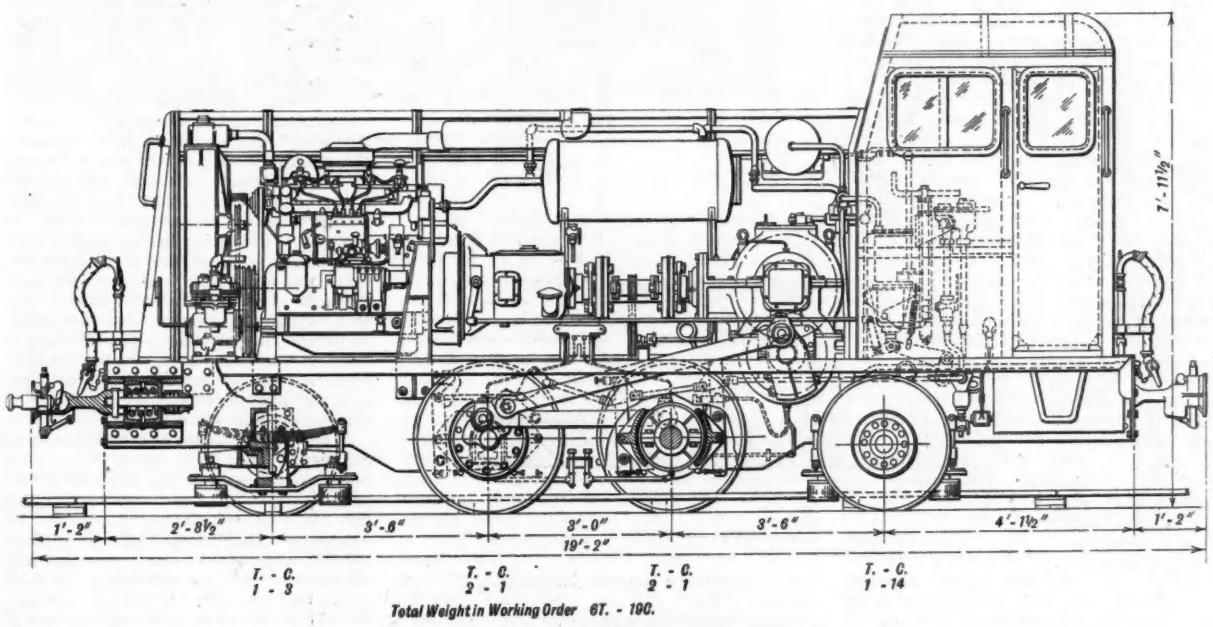
It is considered that the system would show to advantage in hilly and difficult areas for several reasons. The high adhesive factor brought about by the use of pneumatic-tyred wheels on the vehicles makes it possible to negotiate steeper grades with this system than would be economically possible with ordinary railway practice, and the lower curve resistance would make curve compensation by reduction of grades unnecessary. According to the conditions in a district, different designs of relatively cheap tracks can be made, and an important point of economy in this connection is that the weight of steel required in "Uniline" track construction is some 16 tons per mile as compared with over 60 tons in a light railway using 35 lb rails.

A useful feature of the system is that it only requires a bed of concrete or other form of consolidated material a few feet wide and a few inches thick, and no extensive clearing of trees or undergrowth is called for initially. If at a later stage in the development of a project a major road is needed, not only can the "Uniline" be used for its construction but its bed can be incorporated in the road and the track removed for further use elsewhere.

In order to prove its theories and demonstrate the many possibilities of the "Uniline" system, the company has built a line about ½ mile long in Sussex and equipped it with a prototype prime mover and a few load-carrying vehicles. A part of this line and the prime mover can be seen in the photograph we reproduce on this page, and some details of the prime mover construction can be seen in the accompanying drawing.

The track itself consists of a concrete bed some 3ft wide and varying considerably in consistency, finish and thickness. It has curves as low as 60ft radius and in it there are gradients of up to 1 in 13. The guide rails used in this case consist of flat-section, 1¼in wide, grooved on the underside and supported at 3ft intervals on chairs fastened by spikes in the road bed. It should be pointed out here that the method of supporting the rail in a raised position at intervals has a particular advantage when a track is laid on the side of a hill or in districts where drifting sand is encountered. As any water-borne silt carried down a hill or drifting wind-blown sand can flow freely under the rail between the spaced chairs, any danger of obstruction either on the track bed or on the side of the rail is largely eliminated.

The 2–4–2, 7-ton prime mover or power unit has a 90 h.p. Meadows diesel engine and has been designed to haul a load of up to 27 tons at a speed of 25 m.p.h. In it power is transmitted through a four-speed gearbox, a reducing and reversing gearbox, jack shaft and coupling-rods to the two middle pairs of wheels. As a matter of interest, we give a table showing



Total Weight in Working Order 67. - 19C.

GENERAL ARRANGEMENT OF LOCOMOTIVE

the performance of this power unit, but would emphasise that it is a prototype and a unit supplied for a specific system would be designed to suit the particular conditions of loading, gradients, curves, &c., involved. The makers state that the rolling resistance on this prototype stock is about 23 lb per ton on the present track.

In the course of a recent visit to inspect the prototype system we witnessed a demonstration run in extremely bad weather conditions. With mud and water washing over the track during runs with loaded vehicles there was no sign of slipping and the running of the power unit and vehicles was particularly smooth and easy on the level, on curves and on gradients.

Performance Data

Gear	Speed, m.p.h.	Tractive effort, lb	Tons behind drawbar								
			Level	1/500	1/200	1/100	1/50	1/30	1/20	1/15	1/12
1	4·5	4900	195	160	128	96	63	42	29	21	16
2	7·3	3060	118	99	79	58	37	24	15	11	7
3	12·2	1840	61	51	41	30	19	11	6	—	—
4	25	913	27	22	16	11	5	—	—	—	—

British Experimental Pile at Harwell

DETAILS of the construction and composition of BEPO (British Experimental Pile), the larger of the two piles at the Atomic Energy Research Establishment at Harwell, have been published by the Ministry of Supply, following the agreement (announced on November 23, 1950) between the Atomic Energy authorities of Canada, the United Kingdom and the United States on the publication of information. The fundamental design of BEPO was undertaken by the U.K. staff, working at the Montreal Laboratory in Canada during 1945–46. The Department of Atomic Energy at Risley, which was responsible for the engineering design and construction, began work on the project early in 1946. Under the direction of the Department of Atomic Energy, the Ministry of Works began construction in June, 1946, and the work was sufficiently far advanced in two years for the plant to be handed over to the Harwell Research Establishment for final tests and operation.

BEPO is a graphite moderated, air-cooled pile with a central thermal neutron flux of 10^{12} neutron/cm²/sec., a critical loading of 28 tons of uranium metal, and a full uranium load of 40 tons, giving rise to an excess reactivity which can be used for producing isotopes or for experimental purposes. The air-cooling system was designed to limit the maximum surface temperature of the fuel elements to 200 deg. Cent. Loading to critical size took place on July 5, 1948, the uranium being added channel by channel until the reaction became divergent. The power of the pile was continuously monitored in the sub-critical state by specially made measuring instruments and, when the pile diverged, the power was permitted to rise to 50W, with no coolant flowing, before the reaction was shut down by the automatic safety system. This was followed in the ensuing months by a gradual work-up to full power, the design maximum flux being reached by the Christmas of 1948.

As Harwell was established on a vacated aerodrome, which included four large hangars, it was possible for the construction of the pile to proceed at once, under cover, by using one of them as the pile building, although a section of the roof had to be raised 20ft to provide additional head-room above the pile for handling tall experimental equipment. A new building was needed for the cooling air exhausters, and it was constructed adjacent to the selected hangar, to which it is connected by underground air and service ducts.

A considerable volume of air is required to cool the pile (about 180,000 cubic feet per minute); it is drawn through the pile in a single-pass system by a number of exhausters situated between the pile and the main exhaust stack. Filters are installed in the air intake to clean the air before it is passed through the pile and another set between the pile and the compressors to remove any trace of radioactive dust which might arise in the pile itself before the air reaches the main machinery, which discharges into the base of a 200ft high stack.

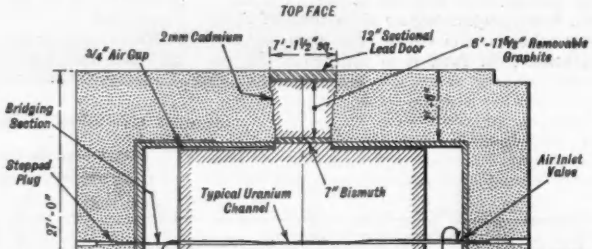


DIAGRAM OF BEPO

Since materials introduced into the pile are radioactive on removal, there is within the pile building a concrete storage block, with accommodation for some 5 tons of irradiated uranium cartridges (usually called "slugs") and numerous other cells, where irradiated materials can be stored temporarily on removal from the pile, until they have decayed sufficiently for safe handling. Irradiated material from the pile has to be withdrawn direct from the pile into lead flasks and handling of these heavy flasks is facilitated by overhead cranes in the pile building.

Construction

The general construction of the pile itself is shown in the accompanying diagram. The reacting part is a cube of graphite of 26ft side, through which pass 1849 channels, about 3½ square inches in cross-section and pitched at 7½in centres. The central 900 of these channels can accommodate bars of uranium machined into cylindrical rods, 12in long by 0·9in diameter, encased in aluminium to prevent oxidation of the uranium and the escape of fission products into the cooling air stream.

Twenty uranium bars are included in each channel, leaving 3ft of empty channel at each end. The channels are loaded radially outwards from the centre to form a right cylinder of 10ft radius and 20ft long. The remainder of the graphite around this central core serves as a reflector to neutrons, which would otherwise escape from the central system.

In addition to the main channels, this graphite moderator is perforated with holes for experimental purposes, so that the actual structure is somewhat complicated. It is built up of standard blocks, each 7½in by 7½in by 29in long with channels machined in their surfaces, which provide, when assembled, all the necessary holes. A total of 850 tons of graphite required to be machined into some 25,000 blocks, with more than sixty variations in the basic types, and this work was executed in a workshop specially erected for the purpose at Harwell. The general machining tolerance adopted was ±0·0025in on all dimensions and the accuracy maintained was such that the total height of the 26ft stack, when completed, was correct to within 0·03in. From the top and from one side cubes of graphite "thermal columns" project from the main moderator. Because of their distance in graphite from the nearest source of fast neutrons, these columns provide a source of almost pure thermal neutrons.

A general view of the pile under construction is given in the photograph reproduced opposite. The 900 central channels are connected at both the air inlet and air outlet ends by headers 4ft wide and extending over the whole graphite face. The headers are connected to the 10ft by 8ft underground ducts of the main air system. The main outer structure of the pile consists of a reinforced concrete and steel shell lined with 6in thick cast iron plates, and constitutes the biological shield for attenuating the intense radioactivity within the pile. The radiation level outside, when the pile is running at full power, is only twice that which exists when the pile is fully shut down, thus ensuring that the sensitive instruments used for experimental work are not adversely affected by background activity.

A large initial attenuation of thermal neutrons and gamma rays is provided by the 6in cast iron shield, so that the bulk of the radiation energy escaping from the reflector is converted into heat in a conducting and heat resisting material, from which it can be easily transferred to the cooling air stream circulating past the sides of the cast iron, so avoiding high temperatures in the concrete.

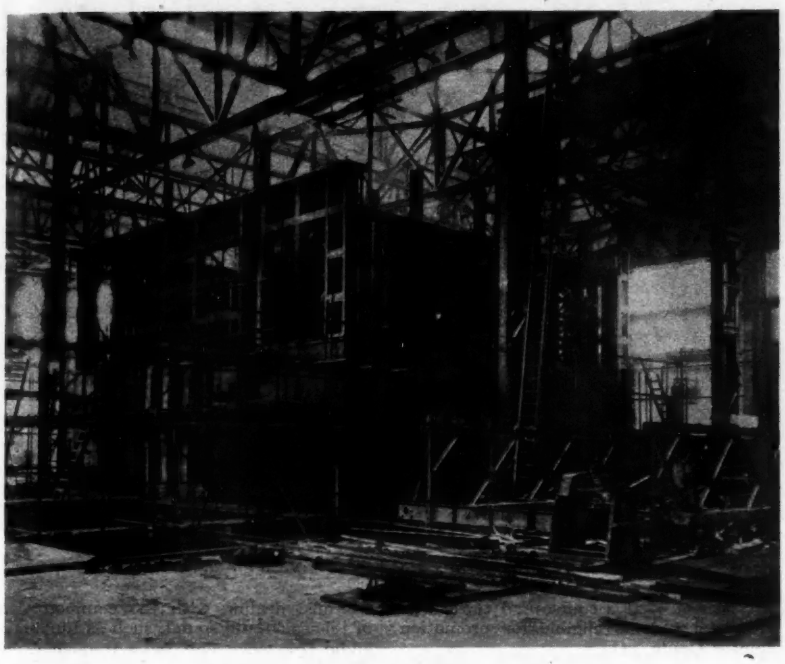
When the graphite moderator was stacked, stringent precautions were taken to ensure clean conditions so as to exclude dust, and other impurities with high capture cross-section for neutrons, which might prevent the pile reacting. To obtain these conditions (not usually available on a construction site), the shield was built as a complete box, the air ducts and all holes through the shield sealed off, the inside of the pile meticulously cleaned and lightly pressurised with clean air before graphite stacking was started. The entire shield therefore had to be constructed as a unit and one of the problems in the construction of the pile was the extreme accuracy with which the pile shield, comprising some 3000 tons of concrete and 600 tons of steel, had to be assembled in order that continuity and

alignment of the 3800 holes common to both graphite and shield was preserved.

The method adopted was first to level and set the cast iron base plates on which the graphite is stacked to within ±0·01in, then to erect on this base the steel frame structure of walls and roof. On this structure the 6in cast iron shield plates and the tubes through the shield were set to ±0·01 per cent in 3ft "lifts," each lift being concreted in turn, great care being exercised to ensure that the concrete penetrated to all interstices in the shield and that no voids or cracks were left to provide subsequent leakage paths for radiation.

Loading, Cooling and Control

The pile is loaded by pushing in a row of slugs from the charge face of the pile and unloaded by means of steel push-rods, which push the irradiated uranium slugs out through the unload face into a lead-shielded container. A bridging section is provided connecting each uranium air channel with a hole through the shields, so that the uranium bar can cross the air headers. The holes through the shield are, of course, plugged to prevent the escape of radiation at all times other than when an individual channel is being loaded or unloaded. It can be seen from the illustration that all holes through the shield are stepped, so that no direct path is provided for escape of radiation. Loading and unloading machines are carried on 12-ton hydraulic hoists, extending the width of the pile, and can be positioned accurately to any horizontal row of shield holes on the load and unload faces of the pile and traversed on the hoists to select the requisite hole in a given horizontal row.



THE PILE DURING CONSTRUCTION

As already mentioned, the pile is cooled by induced air draught in preference to forced draught, to establish a negative pressure within the pile with respect to atmosphere, thus ensuring that any leakage of air at the many holes through the shield wall would involve fresh air inwards and not activated air or dust outwards. Although this provision results in less advantageous conditions at the exhausters than a forced draught system, it is fully justified in practice by the greater simplicity of the experimental arrangements.

The basis for the specification of the cooling system was the air quantity and pressure drop required through a central uranium channel to keep the temperature of the hottest uranium cartridge below 200 deg. Cent. for a rate of heat release corresponding to a total power of 4MW The heat release per unit length along a channel and from channel to channel across the pile is not uniform, since the distribution of neutrons in a pile is a maximum in the centre and falls off towards boundaries. To economise in pumping power, the air flow down each channel is adjusted to suit its heat release. Five 1400 h.p. single-stage compressors, running as exhausters, are installed to draw the air through the pile, of which four are required for the full power conditions. The drive for each exhauster is from a direct coupled 11kV, three-phase induction motor, supplied from the National Grid through a suitable step-down transformer and control gear.

The pile is controlled by introducing four boron carbide-filled hollow steel rods 2in in diameter horizontally into the side of the pile so that, when fully inserted, the rods extend across the reacting core. These rods can be accurately positioned from push buttons in the control room. In addition there is a second system of ten similar rods, known as shut-down rods, operating vertically in the pile and having two positions only—right in or out.

When both systems are fully inserted the fission rate within the pile is about a milliwatt, since the boron in the rods absorbs thermal neutrons very strongly. The start-up procedure is first to withdraw the shut-off rods then the control rods, to a position where it is known that the pile power will rise at a reasonable rate; when the desired power is reached the rods are moved in until the indicated power level is steady. In subsequent operation compensation for self-induced changes in the reactivity of the pile must be made by control rod movement. These changes occur through variation in the graphite and uranium temperatures and the build-up of certain fission products with a high neutron capture cross-section. All the self-induced reactivity changes tend to shut down the pile so that, subsequent to start up, a continued outward withdrawal of the control rods is necessary for several days, until steady conditions are reached. This adjustment was originally effected by hand, but an automatic regulating system has now been installed, which not only relieves the operator of a tedious task but also maintains a more steady power level than can be achieved by hand control—a desirable characteristic for experimental work. The shut-down rods, controlled by compressed air, are available at all times to shut down the pile rapidly, in under a second, if conditions of fault should arise in the plant.

The power of the pile is measured in two ways. The first is by a heat balance measurement in the cooling air. Though accurate, this method has a slow response because of the inherent thermal time lags of the system; therefore it is no use for the instantaneous control of the pile. The second method is by measuring the thermal neutron flux. This method, which is virtually instantaneous, employs ionisation chambers within the pile shield, which produce a small electric current proportional to the thermal neutron flux in which they are immersed; the output is amplified and displayed on suitable instruments in the control room.

In the control room are instruments indicating activity gained by cooling air on passing through the pile, while gamma and thermal neutron health monitors, permanently installed around the pile, are connected up in a similar way.

In addition to the many lessons learnt during the design, construction and initial start-up of the pile, in two years of full power operation, BEPO has been a valuable research tool. All the facilities provided have been exploited, neutron beams from the thermal columns have been used in many nuclear experiments, while physicists, chemists, metallurgists and biologists have been able to augment their knowledge of the effects of radiation on matter. The rapidly growing demand for radioactive isotopes in all fields of scientific research and for industry has been met by production in BEPO, the largest radioactive source so far handled being a 500 curie cobalt source for biological work. In the technological field experience is being gained, which has direct application in the development of nuclear power, important aspects being the development of control equipment, observation of the effects of radiation on structural materials and the study of shielding design.

Hunter-Hazell Collection of Historic Cables

An exhibition illustrating the historical development of power cables from 1882 until the present day is being held in the Display Centre of British Insulated Callender's Cables, Ltd., at 21, Bloomsbury Street, London, W.C.1, until Friday, April 27th. The exhibition was formally opened at a reception on April 11th, when Sir Alexander Roger, chairman of the company, presented Lord Citrine, chairman of the British Electricity Authority, with a souvenir incorporating sample lengths of the first five 10kV cables to be made in this country and laid in London. These cables were the Fowler-Waring concentric insulated with jute fibre, impregnated with petroleum residue (1889); the Ferranti tubular main, paper insulated and impregnated with ozokerite wax (1890); the Siemens non-hygroscopic cable insulated with a compound of ozokerite and oil (1896); the B.I. Wire Company's flexible paper-insulated cable, using helical paper tapes impregnated with resin oil (1896), and the B.I. Wire Company's flexible concentric cable embodying helical paper tapes and segmental conductors to carry 7·5MVA (1898).

Among the interesting cables displayed in the collection are the Edison two-core tubes which were used in Holborn in 1882, components of the Crompton copper strip system as used in 1898, and a complete range of 10kV mains of the 1890 period, including Ferranti's own demonstration joint for his tubular mains. Coming to more recent times, the exhibition includes the first oil-filled cable made by L. Emanueli in 1920, and many oil and gas-pressure cables evolved during the last twenty years.

Admission to the exhibition is by tickets obtainable at the address given above, or at any U.K. branch offices of the British Insulated Callender's Cables, Ltd. Because of the historical and technical interest of the exhibits the Hunter-Hazell Cable Collection has been accepted for display in the exhibition galleries of the Science Museum, South Kensington, concurrently with the Festival of Britain.

B.B.C. Engineering Training School

DURING the war the B.B.C. found itself faced with a serious loss of trained staff to the fighting services, and in 1942 the engineering division started a scheme of intensive training of engineers from other branches of electrical engineering. When this source was exhausted the training of youths aged sixteen, and of women operators aged from twenty-one to thirty, was instituted. The training section responsible for this work was then a part of the operations and maintenance department.

There was a central school in London and a number of smaller schools at certain B.B.C. centres in the provinces. At the central school one month's preliminary training was given in the laws of electricity, acoustics and radio propagation, but, in the provinces, the students spent two months in lectures and operational work on the apparatus which they were eventually to handle. Training was given on transmission, control-room and recording apparatus and about 2500 students were trained during the war years. In addition to these schools, at a number of the larger stations and regional centres, instructors were appointed to bring the youths and women recruits up to a standard suitable for them to profit from the instruction given at the school.

In 1945 the section was elevated to the status of a department and the present Head, Dr. K. R. Sturley, M.I.E.E., was appointed. It was realised that separate schools and station instructors were uneconomical and could not provide the proper facilities needed for full-scale training. Accordingly, it was decided to centralise the whole department and this was done at Wood Norton Hall, Evesham, in March, 1946. The total number of students who have passed through the Wood Norton school is 1100 and, during the past five years, considerable developments have taken place in training for the sound and television services.

The chief responsibility of the engineering training department, which we visited recently, is that of training engineers and technical assistants in the theoretical and practical aspects of B.B.C. technique and equipment for the sound and television services. It does not attempt to give basic training in electrical engineering such as is available in the universities, technical colleges and other existing institutions, but is concerned with the application of basic principles to the equipment and methods used by the B.B.C. Students are encouraged to undertake courses of study on their own initiative, so that their standard of attainment in mathematics and physics will enable them to make fullest use of the courses provided by the training department.

Training Courses

The main activity of the department is concerned with two kinds of staff, the new recruit, who enters as a technical assistant, and the engineer. The engineer is generally, though not always, a former technical assistant with some years of experience in B.B.C. work. The technical assistant operates the apparatus under supervision; the engineer may be concerned with supervision of technical assistants and the maintenance of apparatus, or with development, design, research or engineering administration. An important development has been that of refresher courses for senior staff concentrating on the presentation of new developments and techniques. Training has also been given to non-engineering staff known as programme operators, who are responsible for the technical control and balance of the programme output from the studio. On the engineering side there are five kinds of courses: initial entry, promotion, refresher, conversion and workshop.

Initial entry courses are held for new staff of the technical assistant grade, recruited for duty in the operations and maintenance department; the technical assistant generally starts this twelve-weeks' course during the second six months of his engagement. The first five weeks are spent on instruction in the fundamental principles of radio engineering, the remaining seven weeks being devoted to the operation and simple maintenance of the particular B.B.C. equipment which the technical assistant will have to use.

Promotion courses last for twelve weeks and are taken by technical assistants who have had to prove before a specially constituted board that they have reached a satisfactory standard of technical knowledge. The first part of the course (six weeks) deals with more advanced principles of broadcast engineering, whilst the second part (six weeks) is concerned with the application of these principles to B.B.C. equipment and practice. An examination is held at the end of this course and those who are successful become eligible for promotion to Engineer Grade "C."

Refresher courses (usually two weeks) for senior staff are held as demand arises and as the other work of the department permits. The subjects of the thirty-five courses already undertaken have ranged from new developments and techniques to the analysis and illustration of general principles underlying well-established procedure. The bias is always towards the work of the department from which the staff have been drawn.

Conversion courses are specially organised for staff changing from one department of the engineering division to another. For example, staff may be required to transfer from the sound to the television service, or from transmitters to studio control rooms or recording. The courses are normally planned for a five-weeks' period and so far there have been nine.

Apart from the service provided for the engineering division, the department is responsible for the engineering training of members of the programme operations departments. For programme operations work artistic appreciation is at least as important as technical understanding and the staff cannot be expected to possess a high degree of scientific training. The aim of the department has been the provision of sufficient technical knowledge to enable them to interpret the results and to get the best possible performance from the studios and the apparatus which they have to use.

When the department first began at Wood Norton, the television service had not been re-established after the war, so that only recruits for the sound service were in training. It was not until 1948 that the first television students arrived and they were placed in the charge of the one instructor then allocated to television. It soon became obvious that television developments would increase so rapidly and cover so wide a field that one instructor would be inadequate. Steps were immediately taken to give all members of the teaching staff some part to play in television instruction and the whole department is now as fully occupied with television as with sound. This broadening of activities naturally led to a reconsideration of the organisation of the department and the question arose whether there should be a division between sound and television, or a selection of the common elements of sound and television. It was decided, finally, that the more logical division was into three sections, dealing with the common elements of television and sound, such as fundamentals, audio frequency and radio frequency and by this reorganisation the department has been able to cope satisfactorily with all its commitments.

PLOTTING POLAR DIAGRAM OF V.H.F. AERIAL

Organisation of the Department

Under the head and assistant head there are three main branches, concerned with instruction, instruction writing and general management. The three instructional sections—fundamentals, audio frequency and radio frequency—are each in the charge of a senior instructor. In the fundamentals section there are four instructors under the senior instructor, and they are concerned with teaching the fundamentals of electrical engineering and radio measurements, physics (light and sound) and with mathematics. In the audio frequency section there are three instructors, dealing with studio control rooms and recording practice, line and network theory, together with an instructor on acoustics, specially for training programme operators. In the radio frequency section there are three instructors who deal with transmitters, camera tubes for television and wideband amplification, with particular reference to pulses and transients. Exclusive of the head and assistant head, the technical instructions section, the administration staff and the workshop instructor, there are thus fourteen instructors.

The Fundamentals and Measurement Section

To give the student sufficient knowledge to understand the theoretical and practical aspects

of B.B.C. equipment, fundamental instruction is offered, supported by suitable experimental work. The work is naturally of a lower technical standard for the technical assistants than for the engineers. During this time exercise classes provide an opportunity for the necessary practice in the handling of circuit problems, so that work covered in the two other specialist sections may proceed smoothly. When the scope of a course does not justify a division into fundamental and specialist sections, e.g., the fourteen-day refresher course, specific lectures and laboratory work in electrical and radio principles are undertaken by the fundamentals section.

The laboratory is arranged to accommodate a class of forty students, who are normally grouped in threes. The experiments are designed to illustrate basic principles and do not require specialist knowledge. To allow the maximum time for experimental work, the written work is reduced as much as possible. Before carrying out an experiment each student receives a laboratory sheet detailing the object and nature of the experiment, the equipment required and the general procedure. He has only to enter up the results of the experiment, plot the necessary graph and write up his conclusions, after suitable discussion with and questioning by the instructor. Despite its possible limitations, this procedure makes the best use of the time available.

A single example will serve to illustrate the importance that is attached to simple demonstrations. To teach the principles of a.c. rectification and its measurement an a.c. supply is fed to a lamp through a half-wave rectifier, the current being measured by a d.c. meter. When an inductor is connected across the lamp the brightness of the latter increases but the current measured by the meter is decreased. Inspection of curr nt waveform by the cathode-ray tube shows that this reduction is caused by the introduction of an a.c. component in the current flowing through the lamp.

The Audio Frequency Section

The audio frequency section is concerned with the theory and practice of studio control room and outside broadcasting apparatus and recording and line equipment for television and sound. The engineering training of programme operators is another of its important activities. Since the work of this section is concerned with sound and its amplification and distribution, the effect of sound vibrations in microphones and loudspeakers, and of electrical vibrations in amplifiers and oscillators must be clearly presented. Use is made of analogy whenever possible and demonstrations are arranged, using one medium to explain what is happening in another. Laboratories are available for studying the action of microphones and loudspeakers, the measurement of amplification and of line characteristics, and the theory and practice of disc and magnetic tape recording. Two large studios are available for experiment in studio acoustics. A large, well equipped control room and a small, single-channel control room are used to give operational experience in main and subsidiary programme distribution work. Apparatus is also available for training programme operators to recognise distortion in studio apparatus.

A good example of the teaching technique is the simple but striking method used to illustrate wave propagation in a string vibrating in one plane, under the influence of a motor-driven eccentric at one end of the string. The effect of terminating the string by its characteristic impedance and the difference between standing and travelling waves is vividly demonstrated by the stroboscopic effect produced by an intermittently flashing neon lamp.

Another demonstration uses the absorption pipe to show the analogy between propagation of sound down a pipe and of electromagnetic waves along a line. A quarter-wave length resonator is inserted in the pipe and illustrates the same phenomenon as a quarter-wave length stub on an aerial feeder line.

Testing Frequency Modulation Transmitter

Radio Frequency Section

The radio frequency section provides instruction relating to the theory and practice of aerials and the operation and maintenance of transmitters for sound and television. It is concerned with the characteristics of camera tubes and the features of amplifiers for pulses and transients and also with receivers for television. All types of B.B.C. transmitters (amplitude and frequency-modulated) are studied, starting from the crystal drive and ending at the output of the final r.f. amplifier to the aerial feeder line. The modulation chain from the programme input equipment is also examined.

A great part of the transmitter work is concerned with high tension, filament heating, grid bias and other supplies, together with protective and interlocking devices. Monitoring, frequency checking, noise and distortion measuring apparatus are reviewed. In the laboratories work is carried out on a 7kW medium frequency transmitter; other lower power medium frequency a.m. transmitters are available for more fundamental experiments. A 90 Mc/s f.m. transmitter is used to give practice in handling very high frequencies. One of our illustrations shows students adjusting an f.m. transmitter. Two bays of programme input equipment provide experience on tone sources, programme amplifiers, attenuators, peak programme meters, &c.

A separate aerials laboratory has been equipped so that all kinds of aerial systems can be tested and a good selection of r.f. bridges allows measurements to be made on the impedance of aerials and transmission lines. An example of outdoor plotting work is illustrated herewith. There is a 7kW transmitter, which can be coupled to various forms of aerial, and the design of matching networks for this is a part of the practical instruction. Qualitative examination of polar diagrams is carried out at 3000 Mc/s, and a wave-guide test-bench provides numerous ultra-high-frequency experiments. The theory of the design and operation of communication receivers, broad band amplifiers for aerial switching and distribution, signal generators, receiver test equipment and field strength apparatus, are given considerable attention in training staff for the monitoring and frequency measurements carried out at the B.B.C. stations at Tatsfield and Caversham. Practical work is provided in a well equipped receiver laboratory.

Pulse technique for television provides a wide field for training, and television students are given instruction, which ranges from the master oscillator pulse generator through pulse-shaping and mixing circuits, delay networks, multivibrators, cathode followers, to the final television video waveform. The theory of light and photoelectricity as far as it affects the television camera is studied and this is followed by camera channel and control-room circuitry, with exercise classes and laboratory work. Video frequency amplifiers, stabilised power supplies, d.c. restoration and black level clamping all receive attention. Practical work is carried out on pulse circuits, frequency dividers, differentiating and integrating circuits, constant impedance networks, &c.

Wood Norton Hall

The premises occupied by the training department at Wood Norton include the main house built by the Duc d'Aumale, fourth son of Louis Philippe, and enlarged in 1891 by his nephew, the Duc d'Orleans, claimant to the throne of France, who maintained the house in regal style until he left it in 1911. The entrance gates to the main drive are copies of originals which formerly gave access to one of the principal entrances to the grounds of the Palace of Versailles. The house is used for class rooms, laboratories and offices, and an extension has been made by building a number of studios and the transmitter laboratory. In adjacent buildings and huts there are more laboratories, one containing a complete recording and reproducing channel. Students are housed in dormitories, which can accommodate up to 100 in two-bedded rooms. There is a large dining room, capable of seating all students and staff at one time, a large rest room and a well-equipped sick bay with two wards and accommodation for the resident nurse.

Awards to Graduate Scientists.—The Under-Secretary of State for the Home Department was asked recently in Parliament by what amount it was proposed to reduce the expenditure of the Department of Scientific and Industrial Research on grants to graduate scientists for research training in the year 1951–52, as compared with 1950–51; the anticipated reduction in the number of grants for the period, and the grounds for the reduction in view of the general shortage of trained scientists in industry and in research institutions. In his reply, the Under-Secretary said that there would be no reduction. In fact, the estimates for this year provided for £246,000 compared with £230,000 in 1950—51. That would allow for about 350 new awards in 1951, as against 374 in 1950. The Under-Secretary pointed out, however, that the sum provided in any one year had to cover not only new awards, but those continued from preceding years. He added that the present estimate of 350 awards in 1951 should be compared with the eighty or so new awards made annually in the pre-war years.

THE ENGINEER

Vol. CXCI APRIL 20, 1951 No. 4969

Contents

PAGE

LEADING ARTICLES—
Railway Freights and Fares ... 512
Rotary Wing Development ... 512

SPECIAL ARTICLES—
Historic Development of the Theory of the Flow of Water in Canals and Rivers. No. II. (Illus) 498
Present-Day Locomotive Working in Great Britain. No. I. (Illus.) ... 501
Present Speed Level on British Railways ... 517
T.S.S. "Ocean Monarch." No. I. (Illus.) ... 516
Use of a Pitot Tube in a Dust-Laden Gas Stream. (Illus.) ... 503

Automatic Car Transmission System. (Illus.) ... 520
B.B.C. Engineering Training School. (Illus.) ... 510
British Experimental Pile at Harwell. (Illus.) ... 508
Expansion of Oil-from-Coal Project ... 521
Heat Unit ... 517
Hunter-Hazell Collection of Historic Cables ... 509
Light Alloys in Monotower Crane Construction. (Illus.) 519
Physical Society's Exhibition. No. III. (Illus.) ... 505
South African Water Supply Scheme (Illus.) ... 522
Steam Shunting Locomotives for Steel Works. (Illus.) ... 519
"Unilino" Transport System (Illus.) ... 507

LETTERS TO THE EDITOR—
Boiler Insurance ... 513
Coastwise Cargo Ships ... 513
Electric Traction Problems ... 513
Vibration Test Equipment for Turbine Blades ... 513

PAGE

LITERATURE ... 515
Books Received ... 515
Short Notices ... 515

OBITUARY—
Sir Charles Bressey ... 514
Harry Davies ... 515

A SEVEN-DAY JOURNAL ... 497
Association of Supervising Electrical Engineers
F.B.I. and Railway Freight Charges
Iron and Steel Productivity Team
Passenger Transport Charges
Raw Material Supplies
Steam Piping for High Pressures

NEWS AND NOTES—
American Engineering News ... 523
British Patent Specifications. (Illus.) ... 527
Contracts ... 528
Forthcoming Engagements ... 528
French Engineering News ... 524
Industrial and Labour Notes ... 525
Notes and Memoranda ... 526
Personal and Business ... 526

RAILWAY FREIGHTS AND FARES

AT the end of last week the British Transport Commission announced that it had submitted to the Transport Tribunal a scheme for substantially increasing passenger fares on the railways and on London Transport road services. That announcement was made just before there came into effect the decision to increase railway freight charges by 10 per cent as from last Monday and just after the issue to the Press by the Federation of British Industries of a letter to the Minister of Transport protesting against the increase. Those events reveal the difficulties that the Commission continues to meet in balancing its accounts and the growing indignation of industry at the repeated increases in its transport costs.

If argument is to be based solely on the relationship between wages and other rising costs of the railways and the fares and freights that are to be charged, there is of course, justification for the increases in freight rates and the proposed increases in fares. Since 1949 wages have increased by £25 million annually and, over the same period (excluding the consequences of the recent Budget) petrol and oil costs have gone up £6 million, and coal, tyres and maintenance materials £3 million each. The Commission has suffered deficits of £5 million in 1948, £20 million in 1949 and £15 million (estimated) in 1950, despite an increase of freight charges a year ago. Early this year the Commission estimated that it was faced with a further deficit of £21 million in 1951 unless something were done to increase its receipts and in spite of certain economies that could be made. It therefore applied to the Minister for an immediate increase in freight charges and now approaches the Transport Tribunal for an increase in passenger fares. In further defence of its actions it pleads that by comparison with pre-war conditions passenger transport is still one of the least expensive commodities and services available in this country. Even if fares are increased, the average cost of travel will be only about 75 per cent above pre-war in London and 90 per cent elsewhere. As an argument it is logical. But is it realistic to calculate changes only in relation to costs? Should not the effect of raising charges and fares also be assessed against the consequences upon usage? If the consequence of levying increased charges is likely, as it is on the railways, to lead to a substantial contraction in business done, a wise firm would surely seek actively some other means of balancing its accounts. As the Federation points out in its protest, "the mere passing on of increased costs to the transport user will not of itself remedy the basic problem of the railways, for traffic will continue to drift from the railways to other means which will provide cheaper rates and more efficient service." The continued increase in the number of "C" licensed road vehicles illustrates that very point. Moreover, the Commission cannot safely assess its position without looking to the future. Before the war the railways lost much passenger traffic to the private car. But they retained at least the advantages over longer distances of a higher speed and greater comfort. Unless, however, railway speeds can be raised and new rolling stock be more rapidly introduced those advantages may soon disappear. For the modern post-war car can support so high an average speed that, door to door, even over long distances, it can equal present-day rail speeds, while it is so well sprung that it provides riding qualities almost up to railway standards. Had it not been for the need to re-arm, such cars might by now have been reaching the home market in much larger numbers than they actually are. Furthermore, if and when new arterial roads are built, it is probable that coaches and lorries will be permitted to travel along them at speeds in excess of the present limit of 30 m.p.h. That is competition that will have to be met by the railways in the future. Nor does the nationalisation of long-distance road haulage make it any the less necessary that they should meet it.

There is, of course, in this present year no question but that the Transport Commission must either increase its charges or obtain a subsidy from the Government. For even if economies in operating cost are possible—they should be the natural consequence of merging the four large group railways into one organisation—they cannot become effective suddenly. It is, however, obvious that neither repetitive increases in charges and fares, nor the grant of a subsidy can provide a satisfactory solution to the railways' problem of competing with road, sea and air transport in the future. Nor is a satisfactory solution to be found in limiting competition by raising road charges (either through more complete nationalisation of transport, withdrawal or limitation of "C" licences, or further increases of fuel taxation) in an attempt to divert traffic back to the railways. The true answer is to make freightage by rail safer from breakage and pilferage, more convenient and more speedy, and travel faster and more comfortable. Given a free hand, railway engineers could, we believe, do it; they could improve the speed and convenience of rail transport and cheapen its cost. But heavy capital expenditure would be necessary upon improved track, improved rolling stock and improved maintenance and other equipment. That policy of rapid improvement appears to have been the one followed in America, and there are indications that it is being followed in France. Its effect in this country would be twofold. For not only would the use of the railways be made more attractive to the public, but railwaymen themselves would experience a heightened morale, feeling themselves to be working for a go-ahead industry, able to repay them in higher wages for more productive work. They would work the better for it. Unfortunately, under present governmental restrictions upon capital expenditure, that is a policy not open to the Railway Executive. It is, of course, a very difficult problem for the Government—even more particularly so now that the country has decided to re-arm—to decide in which fields the country should spend the limited capital it can afford. But it does seem to us that far too little is being spent upon transport improvement. For an efficient transport system by rail and by road is just as essential to high productivity at low cost as is the adequate equipment of factories.

ROTARY WING DEVELOPMENT

THE report of the Helicopter Committee, lately published by the Ministry of Civil Aviation and noted briefly in our columns, gave a hopeful view of the future of such aircraft, provided that certain desirable improvements could be effected in their design. It suggested that a ten to twelve-passenger machine might be in service by 1954 and a twenty-passenger craft by 1958, but whether these forecasts are fulfilled or not the present official attitude to the whole subject contrasts very favourably with the attitude which prevailed in the middle twenties of this century, when the then Air Ministry had the unhappy idea that the proper form of official encouragement would be the offer of a money prize of £50,000 for the best helicopter produced. The Council of the Royal Aeronautical Society protested emphatically against such a rash inducement,

and it was fortunate that in the event no inventor cared to take the risk then involved in such an adventure. In an interview with the Secretary of State for Air, who at that time was Sir Samuel Hoare, the Council explained that such action, so far from being likely to solve the outstanding problems of flight, would introduce even wider problems of its own, for the helicopter depended for its safety even more than the aeroplane on freedom from power plant failure, whilst introducing extremely complex problems of management and control. The Council also urged the Secretary of State to define the Air Ministry's responsibility for aeronautical research and to follow the Admiralty lead in appointing a civilian of scientific standing to take charge of all its scientific research matters. In due course action in this sense was taken, the prize competition for helicopters was allowed to lapse; costly and somewhat ineffective military experiments with a secret design of helicopter were brought to an end; and Senor Cierva was invited to bring to England his rotary-winged "autogiro," which had already shown its excellent practical qualities in flight.

This action led to the manufacture in Britain of a number of experimental gyroplanes, as they came to be called, and eventually one in which the "windmill" could be mechanically driven at take-off and on a sudden increase of blade pitch could rise off the ground and climb easily and safely under the pull of its tractor airscrew, much as in the case of a normal aeroplane. It seemed to many judges that this development went far towards the production of a safe and practical rotary-wing machine. It was true that it would not provide a vertical climb to height on a windless day, so that it was not a true helicopter in the full sense of the word. But many thought it was near enough. As it happened, however, its application to practical flying was slow, and years passed without its civil use developing nearly as quickly as had been expected; it was really before its time, since there was in those days little call for airline feeder routes, for there was little enterprise to feed; nor did there seem to be any military application. The position is now very different. Air travel has become highly popular and air speeds have risen to a level where lost time in getting to and from airports excites much impatience in the passenger; consequently there is a demand for feeder aircraft capable of travelling at 100 m.p.h. or thereabouts. Rotary wing qualities appear to supply best what is wanted; but which form of rotary-wing craft is going to head this new path it is too early to say.

The change in the commercial prospects of helicopter services is brought out by the Committee in an appendix to its report, which shows four firms of British manufacturers responsible for no less than eleven types of aircraft. All but three of these craft, however, are single-engined types, so that most of them fail to fulfil the Committee's requirement of being multi-engined; nor are many of them considered to be as free as they might be from defects in their rotor systems. Since, in regular operation, blind flying and night flying, with their appropriate landing techniques, will be a normal requirement, it is good to know that development has reached the stage where certificates of airworthiness of the helicopters in use have been endorsed for blind flying. The Committee is doubtless wise, however, to draw attention to the importance of the vibration factor in relation to operation and maintenance, as well as to the personal factor of passenger comfort. The initial service of such craft might well include the carriage of persons, mail and freight on cross-country journeys where transit is at present tardy, and might provide the very necessary connecting link with international airports and seaports. The Committee thinks that with multi-engined craft available a fleet of fifty machines could be progressively absorbed and that after a few years a hundred of them might find steady employment. But it has to be borne in mind that in view of their use so close to large towns and at no great height they shall be so designed as to be as noise-free as possible; hence the proposal, sometimes made, to use reaction jets of some sort to drive the blades will need to be closely controlled.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ELECTRIC TRACTION PROBLEMS

SIR,—Your remarks of February 16th regarding railway electrification, have just come to my notice and I would make the following comments on your leader.

The extra load due to railway electrification would be a tiny fraction of the national demand and in fact the load factor would improve as the peak railway load would occur at night.

The present shortage of generating plant could easily be made good by the time any large electrification could be completed, if necessary, with the aid of locomotive works capacity.

Although not an ideal example, the Southern electrified system is a reliable guide and it should be remembered that a large amount of the electrical and signalling equipment on that system is of equal age to the steam locomotives you mention. Greater economies should therefore result from use of new equipment and from electric freight haulage.

Long stretches of roaring rails occur on the L.M.R. main line; this feature cannot therefore be quoted against electrification. Furthermore, the rough riding of most multiple-unit electric stock is due to the pernicious practice of fitting motors to ordinary trailer coaches (which is, apparently, to be perpetuated by the Railway Executive to-day). A motor-coach designed as such will ride perfectly well. In any event locomotives should be employed in future to secure better use of the electrical equipment.

In conclusion, I must express surprise at the flimsy reasons advanced by you against railway electrification and hope that such defeatist remarks (which do much harm to British prestige abroad) will not in future appear in print.

NOEL DUDLEY

Hayes, Middlesex, April 11th.

VIBRATION TEST EQUIPMENT FOR TURBINE BLADES

SIR,—The article on pages 370–2 of THE ENGINEER, dated March 23rd, by Messrs. A. M. Roberts and A. A. Gregory, is interesting in that it publicises the refinements now applied to the experimental determination of the nodes and frequencies of vibration of turbine and compressor blades.

Their problem involves the use of (*a*) an exciting system to maintain the vibration, and (*b*) means of measuring the frequency, amplitudes and nodal form. The method given for exciting the vibrations of the blade has many advantages, but it appears to involve a very elaborate "box of tricks." The 2 to 1 ratio between the exciting frequency and the oscillation frequency also seems unnecessarily confusing as a diode rectifier in the output of the impulse amplifier reduces the doubled frequency of the magnetic impulses of the circuits represented, to the same frequency as the amplifier a.c. input and the full cycle of the a.c. wave is then available for each impulse. Alternatively, mixing the output from this amplifier with d.c. through a suitable choke, condenser and potentiometer serves equally well. I would inquire of the authors whether small motor generators, similar to those used for exciting the completely bladed turbine wheel, have been tried for single blades or blades in "packs." Experimenters in colleges, with limited funds and equipment, must perforce use versatile pieces of equipment. I have found, for example, that simple magnetic pick-up connected to the input of the amplifier ensures that the blade vibrates, with one of its natural modes, and the choice of which one can be made, within limits, by using a standard beat frequency generator for the starting excitation. Negative feed-back has been used successfully to control the amplitude.

Would not a stroboscope show the positions of the nodes visually, and indicate better whether torsional or transverse modes of vibration were present? This method is certainly satisfactory for the lower frequencies, but the authors' comments on its use for the higher frequencies would be valuable. I have also found that a micrometer head traversed along a bar parallel with the edge of the vibrator, gives an audible indication of high precision and negligible damping, in determining the nodes at this position.

H. THOMPSON

Queen Mary College, London, E.1,
April 13th.

BOILER INSURANCE

SIR,—Your readers may be interested in an experience which recently befell one of our most important industrial clients. A heating installation boiler exploded, causing many thousands of pounds worth of damage to property, serious injury to the boiler man, and many other workpeople narrowly escaped injury. An investigation of the debris failed to prove conclusively that the explosion was caused by internal steam pressure but that it was more probably a flue gas explosion. The insurers, a very well-known company, had a standard clause in their policy excluding damage caused by flue gas explosions and therefore repudiated the claim. Our clients were quite unaware that their explosion risks policy was qualified in this manner and we understand that the additional premium to cover for flue gas explosions is very small indeed.

HUSBAND AND CO

Sheffield, April 13th.

COASTWISE CARGO SHIPS

SIR,—In his recent article in THE ENGINEER, concerning coastwise cargo ships (page 402, March 30th), Mr. Tripp mentioned the "Will Everard." It would perhaps interest readers to note that she is a sailing vessel—rigged as a spitsail mulie barge—and is contemporary with the "Aridity," which Mr. Tripp described.

R. A. SUDELL

Sydenham, S.E. 26, April 11th.

Obituary

SIR CHARLES BRESSEY, C.B.

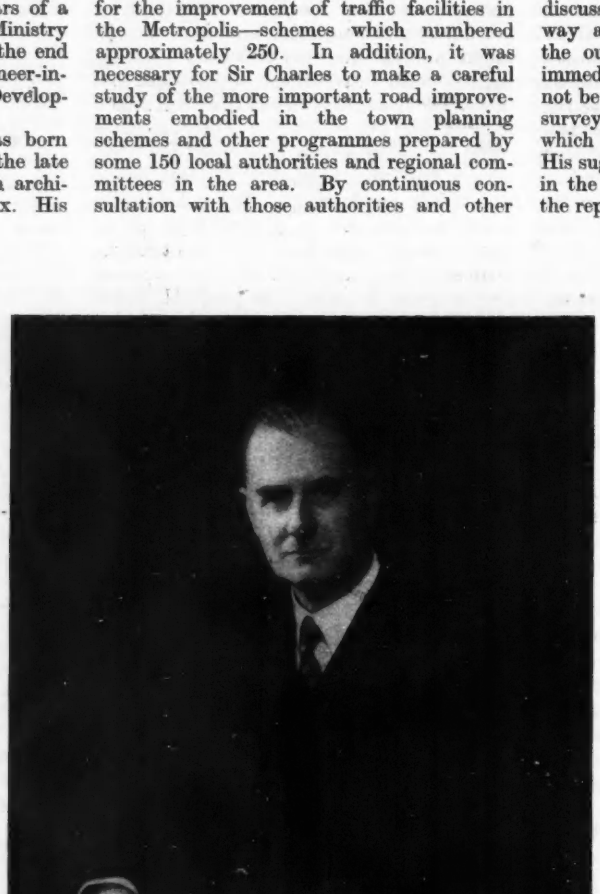
HIGHWAY engineers and surveyors all over the country will learn with deep regret of the death of Sir Charles Bressey, of 3, Fernbank, Church Road, Buckhurst Hill, Essex, which occurred on Saturday, April 14th, in his seventy-eighth year. Sir Charles was a well-known authority on roads and road problems, and, for nearly twenty years of a distinguished career, served with the Ministry of Transport until his retirement at the end of 1938 from the position of engineer-in-charge of the Ministry's Highway Development Survey.

Charles Herbert Bressey, who was born on January 3, 1874, was the son of the late Mr. John T. Bressey, F.R.I.B.A., an architect and surveyor, of Wanstead, Essex. His general education was received at schools in Bremen and Rouen, and at the Forest School, Walthamstow. Bressey's professional career started by his being articled to his father, by which means he gained a good deal of experience in civil engineering and surveying work for local authorities and various industrial undertakings. In the first World War, Sir Charles served as a Lieut.-Colonel in the Royal Engineers under General Sir Henry Maybury, Director of Roads on the Western Front. He was required to spend much of his time handling negotiations over road engineering matters with the French and Belgian staffs, was mentioned in despatches, and was awarded the O.B.E. and the Chevalier Legion d'Honneur. At the end of the war, Sir Charles was appointed a member of the Inter-Allied Commission in charge of Rhine Province communications.

In 1919, Sir Charles was invited to join the staff of the newly formed Ministry of Transport as divisional road engineer (London). At that time he served under his old chief, Sir Henry Maybury, who had been appointed to the position of Director-General of Roads. Two years later, in 1921, Sir Charles was promoted to the post of Chief Engineer (Roads) at the Ministry of Transport, and in 1928 he succeeded Sir Henry Maybury as the Ministry's principal technical officer. He continued in that appointment until 1935, and was thus intimately concerned with most of the road reconstruction and improvement schemes, including the arterial road works which were carried out in the London area during the inter-war years.

Towards the end of 1934 the then Minister of Transport, Mr. Hore-Belisha, announced his decision to put in hand a comprehensive and systematic survey of the highway developments required in the London traffic area during the next thirty years in order to keep pace with the expansion of traffic. Sir Charles was invited to take responsibility for the survey as engineer-in-charge, and Sir Edwin Lutyens, R.A., was appointed to act as consultant. Their terms of reference were "to study and report upon the need for improved communications by road—including the improvement and remodelling of existing roads—in the area of Greater London, and to prepare a highway development plan for that area, incorporating, so far as practicable and desirable, schemes already planned or projected."

The task thus assigned to Sir Charles took three years, during which he made a general study of traffic needs in the area of 1821 square miles covered by the survey, and also examined in detail all the practicable schemes that had been propounded at various times for the improvement of traffic facilities in the Metropolis—schemes which numbered approximately 250. In addition, it was necessary for Sir Charles to make a careful study of the more important road improvements embodied in the town planning schemes and other programmes prepared by some 150 local authorities and regional committees in the area. By continuous consultation with those authorities and other local bodies, Sir Charles was able to ensure that none of the recommendations included in his report were made in ignorance of local factors which ought to be taken into account. The report on the survey was presented to the Minister of Transport and published at the beginning of 1938. It was a document which clearly revealed how carefully Sir Charles, with the assistance of Sir Edwin Lutyens, performed his task. The report dealt with traffic statistics and centres of congestion, and made suggestions about arterial roads, radial roads, motorways, roads over railways, and access to aerodromes. In all, sixty-six road projects were recommended for the area covered by the survey. Sir Charles concluded his report by emphasising that the lines of new routes should be authoritatively laid down for rigorous observance as permanent governing features in the ceaseless development and transformation of the Metropolis, where, hitherto, he claimed, so much uncertainty had prevailed as to the official status of various road schemes which were protected in one area and neglected in another. He also felt that the need for prompt action was imperative, saying that "Londoners would be better advised to embark immediately upon useful road schemes, admittedly imperfect, rather than wait for the emergence of some faultless ideal which will have ceased to be attainable long before it has received approval." The Bressey report was closely studied and fully discussed by engineers, surveyors and highway and other interested authorities, but the outbreak of war in 1939 stopped any immediate action on the proposals. It must not be thought, however, that the exhaustive survey of London's road and traffic problems which Sir Charles made was labour in vain. His suggestions have been taken into account in the preparation of subsequent reports on the replanning of London in the light of post-war needs and development.



SIR CHARLES BRESSEY

In the same year that his report was published, Sir Charles succeeded to the presidential chair of the Royal Institution of Chartered Surveyors. His presidential address, delivered in November, 1938, dealt primarily with road administration and traffic problems, and amplified in greater detail several of the matters raised during his Greater London survey. In the same year, Sir Charles agreed to serve as President of the Junior Institution of Engineers, and his address to that Institution was again a most instructive one on the subject of "Roads and Traffic." One principle, he declared in that address, which had been overlooked for the past twenty years was that of discriminating between roads serving widely different purposes—on the one hand, the great direct route affording "main line" facilities for long-journey traffic, and, on the other hand, the local road traversing and serving groups of villages and townships. On grounds of economy alone, Sir Charles thought we should have to discard the theory that every highway was to be adapted to carry every form of traffic, however ponderous or speedy. Some of the most successful lengths of arterial road constructed in this country, he suggested, were those where differentiation of function had been obtained by restrictions placed upon the utilisation of adjoining land. He went on to express the hope that if the construction of new routes or motorways was to be undertaken on a large scale their course would, where possible, traverse virgin territory to be earmarked in perpetuity for agricultural or recreational purposes.

In addition to his work for these two Institutions, Sir Charles was an honorary member of the Institution of Royal Engineers, and a member of the Institute of Transport, the Institution of Municipal Engineers, the Institution of Highway Engineers, and of the Town Planning Institute. He was also a member of the Permanent International Commission of Road Congresses, a past-chairman of the British Standards Institution's Road Engineering Industry Committee, and a former vice-president of the Institution of Professional Civil Servants. Sir Charles received the

honour of Knighthood in 1935, having been created C.B. in 1930 and C.B.E. in 1924.

HARRY DAVIES

We record with regret the death of Mr. Harry Davies, which occurred, after a long illness, at his home, "West Mead," Caswell Road, Swansea, on April 9th. He had been technical manager of Imperial Chemical Industries, Ltd., Metals Division, Landore, since 1938.

Mr. Davies was educated at King Edward VI Grammar School, Stourbridge, and was subsequently articled to Mr. Joseph Lones, F.I.C., a public analyst. From 1911 to 1915, he studied metallurgy at Birmingham University, where he became a Bowen Research Scholar. In 1916, Mr. Davies was appointed to the metallurgical staff of the Dunlop Rubber Company, Ltd., and a year later he went to Rudge Whitworth, Ltd., as research metallurgist. His next appointment was in 1920 as senior chemist and metallurgist of Elliots Metal Company, Ltd. (later I.C.I., Ltd.), Birmingham, in which post he continued until 1934, when he became chief metallurgist of Imperial Chemical Industries, Ltd., Metals Division, Landore. Mr. Davies was appointed technical manager at Landore in 1938.

For several years Mr. Davies had taken a prominent part in the work of the Institute of Metals, having served for two terms as chairman of the Swansea local section. He was elected to the council of the Institute in March of last year. He was elected a Fellow of the Institution of Metallurgists in 1946, and had been the senior vice-president of the Birmingham Metallurgical Society and secretary of the Birmingham University Metallurgical Society. From 1916 to 1934, while he was working in Birmingham, Mr. Davies lectured regularly on non-ferrous metallurgy at the Birmingham Technical College.

Literature

The Watchmaker's and Clockmaker's Encyclopædic Dictionary. By Donald de Carle, F.B.H.I., London: N.A.G. Press, Ltd., 226, Latymer Court, W.6. Price 30s. net.

A technical dictionary of the kind represented by this volume is by no means easy to compile, correct and illustrate; but its author and illustrator have carried out their tasks exceedingly well, and the result is a distinctly creditable and thoroughly informative work.

Almost every imaginable item that can be used in connection with a watch or clock, or in the tools needed for their manufacture, is to be found in the dictionary, neatly and clearly described, and in many cases shown by a very distinct and well-executed drawing.

The main part of the book consists of a glossary of general terms and includes many scientific and electrical terms as well as those of purely horological origin. Some of the latter terms come strangely to those more familiar with the descriptive terms used in heavier branches of engineering, but the explanations are always well chosen and leave no doubt in the reader's mind. Much of the information included is more detailed than would normally be expected in a "glossary of general terms," instances being the table of altitude, which gives aneroid readings compared with heights in feet from 0 to 20,000ft, tables giving materials for balance springs, and a small table which indicates the colours and temperatures involved in the process of "blueing" polished steel.

It is rather a pity that the drawing illustrating the double three-legged gravity escapement does not maintain the same standard of correctness as the rest. The artist has made the usual mistake of showing both the gravity arms in contact with the pendulum at the same time, and has made things worse by also showing them resting against stop-pins.

The most modern developments in horology have been included as fully as possible, and good examples are the brief description of the "atomic clock" and the pleasingly concise account of the magnetic escapement, which should make its principles clear to everyone.

Either an error, or a difference of terminology seems to have arisen in connection with an entry on page 94, for here a "mandrel" is described as "a face-plate, fitted with 'dogs,' or clips, to hold work during turning, fitted to a lathe, or as a separate self-contained tool." The illustration which accompanies the paragraph shows what most engineers would describe as a hand-driven face-plate lathe!

An aspect of horology which this book, almost more than any other, does bring before the reader is the astonishingly ingenious and diverse pieces of mechanism which have been developed for various purposes in connection with watch and clock construction. Instances are the cams and attached mechanism used to give the equation of time, the "maintaining power" devices used to keep timekeepers going during winding, parts with such entertaining titles as the "all-or-nothing-piece," and the "surprise-piece," which have important functions in the action of repeating watches, the "Tourbillon," and the strange forms of striking control employed on some clocks.

There is one omission which seems a little difficult to understand. Under the heading "Time Recorders," the reader is referred, "See Timing Machines and Timer," and under neither of these is the very widely used factory time recorder even mentioned. As these machines are so extensively used and so essential to industry as to have developed into a large and highly specialised branch of the horological trade, their total neglect is all the more strange. In his reference to "Timing Machines" the author is obviously thinking of watch rate recording machines, which are very different.

After the glossary of general terms there follows a section which is devoted to antique clock and clock case terms. It is one of the peculiarities of horology that it must continue to take account of such things. Clocks are very long-lived machines, and there are hundreds of thousands still in service which number their years by the century. This fact makes this part of the book a very valuable one, and the survey of older kinds of clockwork and clock case-work is reassuringly complete.

Further pages contain a useful section on the metals used in horology, and though the descriptions given are necessarily brief, and might not be considered sufficient by metallurgists, they are quite serviceable enough for this present purpose.

Notes on the marbles and ornamental stones used for clock cases have rather a specialised use, and the same remarks apply to the tables on woods suitable for case-making. However, in both sections the descriptions given are clear and concise.

The next section, which consists of illustrations of mouldings, and a note on the standardisation of supplies of watch "material," by which is meant spare parts and components, is also mainly of trade interest, but the succeeding pages contain one of the most interesting tables we have seen. Each component of a modern watch is illustrated, and its correct title given in English, American (by no means always the same as English), French, German, Italian and Spanish. After that, various sorts of watch hands and winding buttons, and watch cases and glasses are covered.

Tables of the days of the week in various languages, and a similar list of the months of the year follow, and a diagram of the standard time zones is also included, with a list of many cities and large towns and their relative time corrections.

Temperature conversion tables come next, and after that a complete and surprisingly long list of the quarter chimes sounded by clocks in various places.

To complete the volume there is a page of diagrams on styles of gem stone cutting, and eight pages of workshop hints, many of which are distinctly interesting and should prove of value to many people who are not horologists.

SHORT NOTICES

An Outline of the Development of the George Fischer Works. Switzerland: George Fischer, Ltd. Schaffhausen,—This is the first of a series of books being published by George Fischer, Ltd., to mark the 150th anniversary of the founding of its works, which will be celebrated next year. These books will describe the development of this Swiss company, which has been so closely connected with the iron and steel industry, and was founded in Schaffhausen in 1802 by Johann Conrad Fischer. The first book opens with a brief description of origin and early work of the founder of the company and his grandson, George, who succeeded him. George Fischer was responsible for the firm starting to manufacture malleable cast iron in 1860 and tube fittings some four years later. On the death of his father, in 1887, another George, the great-grandson of the founder, took over control of the business and he decided to abandon the forge and the manufacture of files as they were no longer profitable. He introduced the steel foundry in 1888 and in 1895 established a separate malleable cast iron foundry and a fittings factory at Singen-Hohentwiel as a branch of the Schaffhausen works. In 1896 the business was converted to a limited company and it steadily grew until by 1944 its premises covered about 125 acres and provided employment for some 4000 hands. Many interesting details are given on the development of the major interests of the firm, which now include the manufacture of malleable cast iron and tube fittings, steel castings, grey iron castings, machine tools, &c. The book concludes with notes on the close relationship which exists between management and employees and the social activities organised and maintained by the firm. Many excellent photographs are reproduced in the book, which will be of considerable interest to the many friends of the firm in this and other countries. All who read this introduction to the promised series will look forward to the publication of the following parts.

BOOKS RECEIVED

Calculating Instruments and Machines. By Douglas R. Hartree. London: Cambridge University Press, 200, Euston Road, N.W.1. Price 21s.

Irrigation Principles and Practice. By Orson W. Israelsen. Second edition. London: Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 48s.

Atomic Energy for the Layman. By Sir Arthur L. Dixon. London: Chantry Publications, Ltd., 63, Neal Street, Shaftesbury Avenue, W.C.2. Price 8s. 6d.

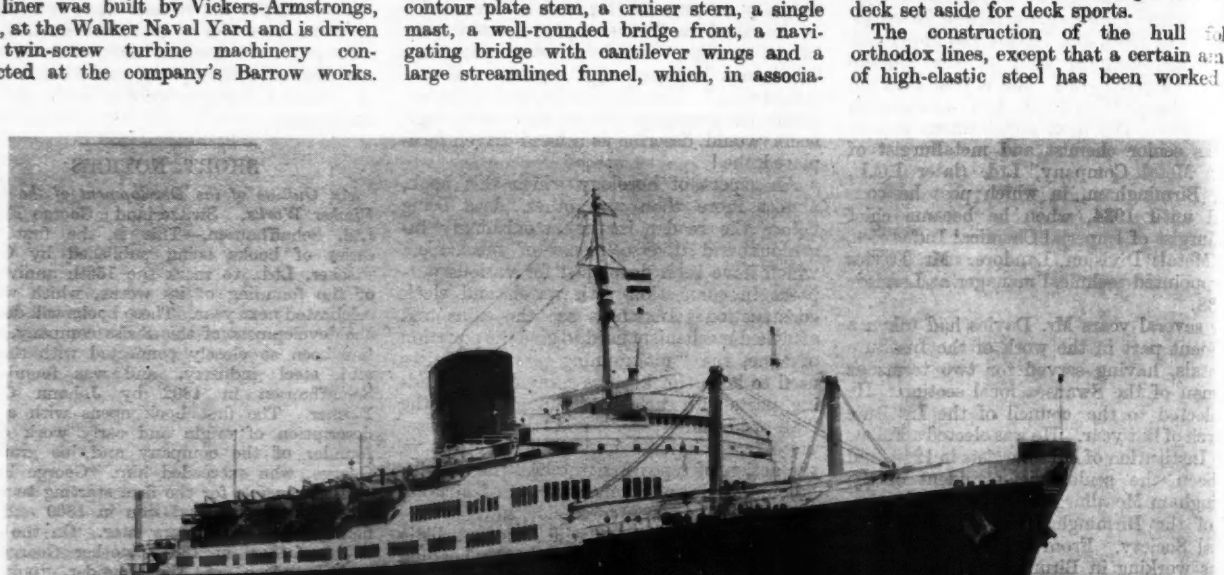
Bearings and How to Fit Them. By Ian Bradley and Norman Hallows. London: Percival Marshall and Co., Ltd., 23, Great Queen Street, W.C.2. Price 3s. 6d.

Metalliferous Mine Surveying. Third edition. By Frederick Winiberg. London: Mining Publications, Ltd., 482, Salisbury House, London Wall, E.C.2. Price 30s.

T.S.S. "Ocean Monarch"

No. I

BEFORE the "Ocean Monarch" left London for New York, whence she will sail on her maiden voyage to Bermuda on May 3rd, we were able to pay a visit of inspection to the ship at the invitation of her owners, Furness, Withy and Co., Ltd. Although limited in size, by the facilities of the ports which she will visit, the new liner is outstanding among the passenger ships completed this year by reason of the particular service which she is intended to serve. The liner was built by Vickers-Armstrongs, Ltd., at the Walker Naval Yard and is driven by twin-screw turbine machinery constructed at the company's Barrow works.



T.S.S. "OCEAN MONARCH"

The "Ocean Monarch" will carry only one class of passengers, and has been designed exclusively for her owner's New York to Bermuda run and for cruising out of New York, to the West Indies, to the ports of Newfoundland and Saint Lawrence.

Dimensions and Particulars

Length overall	516ft 1in
Length between perpendiculars	475ft
Breadth moulded	72ft
Depth to upper deck	39ft
Maximum draught	24ft
Displacement	13,840 tons
Service speed	18 knots
Gross tonnage	13,970 tons
Grain capacity	95,180 cubic feet
Insulation capacity	15,490 cubic feet
Oil fuel	2106 tons
Fresh water	1938 tons
Accommodation:	
Passengers	430
Crew	256

Propelling machinery:
Type: Twin-screw, double-reduction, geared Parsons turbines of Pametrada design
Normal power: 11,500 s.h.p. at 150 propeller r.p.m.
Astern power: 6500 s.h.p.
Steam supply: 425 lb per square inch, 750 deg. Fah.
Boilers: Four Yarrow three-drum design
Steam pressure: 450 lb per square inch

Electrical machinery:
Three W. H. Allen turbo-generators
Rating: 550kW, 220V, d.c.

She will join the "Queen of Bermuda" during the popular seasons and will be available to relieve that ship for special charter voyages. The "Ocean Monarch" takes the place of the "Monarch of Bermuda," which was constructed at the same shipyard in 1931 and gutted by fire while being reconverted after her wartime service. She was eventually rebuilt and, renamed "New Australia," is now engaged in carrying emigrants to Australia.

The pleasing profile of the new liner can be seen in the accompanying illustration. This shows that the ship has a curved raked contour plate stem, a cruiser stern, a single mast, a well-rounded bridge front, a navigating bridge with cantilever wings and a large streamlined funnel, which, in association with deck house tops sloped parallel to the funnel bands, gives a well-balanced appearance.

Design and Construction

The ship has been built under the survey of Lloyd's Register of Shipping to its highest class of passenger ships. It meets, not only the latest requirements of the Ministry of Transport, but complies with the Factory Acts and embodies all the international regulations for safety of life at sea, including those required of British ships sailing out of United States ports. Subdivision to comply with the Ministry of Transport's requirements is effected by eight main transverse watertight bulkheads rising to "B" deck, and further subdivision up to "C" deck is provided by the longitudinal and transverse watertight and oiltight bulkheads forming the fifteen deep tanks for oil and fresh water. The space to port and starboard of the refrigerating machinery compartment is subdivided to form six fresh water and two distilled water tanks. Large cross-connected heeling tanks are constructed in the wings of the engine-room and extend over approximately half its length. There are eighteen double-bottom tanks; numbers one, two and eight are intended for water ballast only, while the remainder are fitted to take either fresh water or water ballast.

There are three continuous steel decks, namely, "A," "B" and "C." which accommodate the passengers and crew, and an orlop deck "D," which extends over the length of number one and number two holds and aft of the engine-room. Above the uppermost continuous deck is the promenade deck, which stretches from the bow almost to the stern; it is mainly for passengers and provides them with ample enclosed deck space. The sun deck is given over to public rooms and cabins and provides a large area of open space. On the boat deck is the navigating and engineer officers' accommodation and there is a raised portion of the deck set aside for deck sports.

The construction of the hull follows orthodox lines, except that a certain amount of high-elastic steel has been worked into the structure in place of mild steel and certain scantlings have been increased above Lloyd's requirements, such as those for the strakes of shell plating above and below the waterline. Arc welding has been employed extensively, in conformity with modern practice, in order to save weight and to permit of the maximum of prefabrication. In a further effort to reduce top weight to a minimum, aluminium alloy has been used for the construction of the outer funnel casing and the captain's deck-house. The plating of "A," "B" and "C" decks is completely welded with the beams welded toe on, while other decks have welded plate butts. Butts of the shell plating and both seams and butts of the inner bottom plating are welded, together with most of the double-bottom structure. The oiltight and watertight bulkheads are welded, while the seams of the shell plating and the frame to shell connections are riveted.

(To be continued)

MEXICO'S OIL INDUSTRY.—According to a report by Reuter, oil production in Mexico last year reached a record total of 73,800,000 barrels, compared with 62,097,308 barrels in 1949. Oil reserves are said to total 1,350,000,000 barrels and reserves of natural gas were calculated to have been 1,663,000 million cubic feet at the end of last year.

The Present Speed Level on British Railways

(Contributed)

NEARLY a century and a quarter ago—actually on October 4, 1830—Stephenson's small four-wheeled locomotive "Planet" (the first steam locomotive built with inside cylinders) is credibly reported to have hauled a special passenger train from Manchester to Liverpool in sixty minutes, which included a stop of two minutes to take water. That was at a time when the Mother of Railways was just setting out to revolutionise land transport. To-day, the comparative slowness of British passenger trains, to say nothing of their unpunctuality, is, by contrast with past performances here and contemporary performances elsewhere, none other than humiliating. Let us take, as an illustrative example, "The Red Dragon," a title given (in the September, 1950, timetable) to the express passenger train leaving Paddington for the West at 5.55 p.m. The first stop is at Swindon, 77½ miles from Paddington, the time allowed being 87 min., corresponding to an average speed of 53·45 m.p.h. This extremely mediocre performance does not appear to warrant even a fabulous title, particularly when we remember that twenty years ago the booked average speed of the "Cheltenham Flyer" over the identical stretch, eastbound, was very close to 70 m.p.h. Notwithstanding this high mean speed, the "Cheltenham Flyer"—which was hauled by engines of the "Castle" class—rarely exceeded a maximum speed of about 84 m.p.h., though the distance of 60 miles between mile post 70 and mile post 10 was frequently covered in about 44 min., giving an average speed of almost exactly 82 m.p.h. and requiring, say, 342 r.p.m. of the driving wheels with the not excessive piston speed of 1483ft per minute. Incidentally, and on this point of steam locomotive driving wheel revolutions per minute, it is appropriate to recall that on the occasion of the well-authenticated fast run (downhill) made by the "Mallard" of the old L.N.E.R. (July 3, 1938), the driving wheel revolutions per minute must have reached the high figure of 525·7 r.p.m. in order to attain a train velocity of 125 m.p.h. the corresponding piston speed—maintained for only a few seconds—being 2278ft per minute. In the case of the large Henschel steam locomotive of 1935 (which was built close to the limit of the Reichsbahn clearance profile) the driving wheel revolutions per minute went to 395·4 for a speed of 108·7 m.p.h., the corresponding piston speed being 1945ft per minute. The driving wheel diameter of the Henschel locomotive was, however, 90·55in, against 80in in the cases of the L.N.E.R. Class "A4 Pacific" and the G.W.R. "Castle" class. Compared with these admittedly exceptional L.N.E.R. and Reichsbahn performances, the 342 r.p.m. of the locomotives hauling the "Cheltenham Flyer" cannot be described as excessive.

If we would check-up with conditions across the Atlantic, it happens that there is a stretch of railway in the United States—between Chicago and Milwaukee—which can be compared, not unfairly, with the line from Paddington to Swindon. The distance separating Chicago from Milwaukee is just 85 miles and the time allowed for the "Morning Hiawatha" is 75 min., calling for a mean speed of almost exactly 68 m.p.h. The line is notably level throughout and free from curves except at the approaches to Chicago and Milwaukee, where considerable caution must be observed owing to level crossings and other obstacles involving severe speed restriction at each end of the run. Notwithstanding these, the "Hiawathas" frequently improve on the booked time, though the load hauled goes to around fourteen heavy air-conditioned coaches. If the "Morning Hiawatha" was re-timed to give the average speed (Paddington to Swindon) of "The Red Dragon," the booked time between Chicago and Milwaukee would need to be increased from 75 min. to as many as 95 min. We can, however, come much nearer home to find railway performances which ought to stimulate our now nationalised British Railways. The timing of the fast trains between Paris (Est) and Strasbourg calls for an average speed of 60 m.p.h. inclusive of two intermediate stops, the steam locomotives employed being of the oil-fired "230-K" class. Each of the lightweight air-conditioned coaches composing the six-coach trains is mounted on two ten-wheeled bogies, the wheels having Michelin pneumatic tyres. The brakes are of automobile type, hydraulically operated, and the carriages are fitted with metal contact shoes for electric track circuiting (signalling) purposes. Accommodation is provided for 176 second-class and 73 first-class passengers.

The recently introduced three-car diesel-electric driven railcar trains operating between Paris (Est) and Bâle—on which meals are served—perform the journey of 327 miles in 320 min. (westbound) and 330 min. (eastbound), inclusive of four intermediate stops in each direction, these stops being at Chaumont, Vesoul, Belfort and Mulhouse. A high degree of punctuality is maintained and the trains weigh about 150 tons and provide seats for 136 passengers. As an indication of things yet to come, one of the new class "CC7000" electric locomotives of the S.N.C.F. on a test carried out some time ago hauled a five-coach train from Paris to Bordeaux (581km) in 266 min., an average speed of 131 km.p.h. (81·4 m.p.h.). It must be admitted that, compared with these American and French performances, "The Red Dragon" cuts a sorry figure. The reputation of our railways for fast and punctual passenger trains is something which we certainly appear to have lost for the time being, and there is clamant need for improvement. The first thing to be recovered is the quality of punctuality, at present at a deplorable level. We can then hope for a substantial increase in speed if not for such accomplishments as that exemplified in the "Cheltenham Flyer." The Mother of Railways must look to her laurels.

The Heat Unit*

By EZER GRIFFITHS, O.B.E., D.Sc., F.R.S.†

THE International Unions of Physics and of Chemistry have recommended that the fundamental unit of heat should be the joule (10^7 ergs), and this has been accepted by the ninth General Conference of Weights and Measures, Paris and Sèvres, 1948.

It has long been realised that the calorie expressed in terms of the heat capacity of water is not a satisfactory thermal unit. In 1895 an inquiry was made, on behalf of a committee of the British Association, to some of the leading European and American physicists to obtain their views as to the unit of heat. The consensus of opinion was strongly in favour of an absolute unit and the majority favoured the joule. Rowland, in particular, urged that the unit of heat should be independent of any system of thermometry and should present the idea of a quantity of heat independent of temperature. Then the first law of thermodynamics would stand, as it should, entirely independent of the second. The joule is independent of the intrinsic properties of any particular substance; it is independent of the temperature scale and is easily realisable with high precision in terms of the electrical units.

TABLE I—*Conversion Factors to Joules for the Various Calories and British Thermal Units*

Conversion factors for various British thermal units		Conversion factors for various calories	
Description of unit	Value in joules	Description of calorie	Value in joules
60·5 deg. Fah. British thermal unit ...	1054·54	International steam table calorie (I.T. cal.)	4·1868
Mean 32–212 deg. Fah. British thermal unit	1055·79	15 deg. calorie ($cal_{15°}$)	4·1855
39 deg. Fah. British thermal unit	1059·52	4 deg. calorie ($cal_{4°}$)	4·2045
Steam table British thermal unit	1055·06	Thermochemical calorie or "defined" calorie	4·1840
		Mean 0–100 deg. Cent. calorie	4·1897

Accuracy in Calorimetric Measurements

It requires careful experimentation to attain an accuracy exceeding a few parts per thousand. With laborious effort and refined equipment it may be possible to reach an accuracy of a few parts per 10,000. In such cases, however, the question of conversion from calories to joules does not usually occur since the apparatus is calibrated by electrical heating and the results are obtained directly in electrical joules.

International Electrical Joules in Terms of Absolute Joules

Until 1948 the "international" system of electrical units was in use and in literature thermal data is often found expressed in terms of international joules. The international system has now been superseded by the absolute system of electrical units, so it is necessary to have a conversion factor to convert international joules to absolute joules. The international units, as realised in the various national laboratories, differed by small amounts, but it has been agreed that the mean international joule of the various laboratories is equal to 1·00019 absolute joules. This difference of

TABLE II—*Values in Absolute Joules of Various Calories*

Description of calorie	Value in joules	Reciprocal of value in joules
International steam table calorie (I.T. cal.)	4·1868	0·23885
15 deg. calorie ($cal_{15°}$)	4·1855	0·23892
4 deg. calorie ($cal_{4°}$)	4·2045*	0·23784
Thermochemical calorie or "defined" calorie	4·1840	0·23901
Mean 0–100 deg. Cent. calorie	4·1897*	0·23868

* The values are not definite to this order of accuracy, but are given to five and six figures for the sake of uniformity.

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about two parts in 10,000 between the value of the joule in the two systems is outside the limits of accuracy of most calorimetric measurements, but when results are given to four significant figures it is necessary to take this into account.

Conversion Factors from Calories to Joules

In Table II the values in absolute joules of the various calories now in use are given. Explanations of these units are given later.

Table III—*Conversion Factors for Various British Thermal Units*

Description of unit	Value in joules	Reciprocal of value in joules
60·5 deg. Fah. British thermal unit	1054·54*	0·00094828
Mean 32–212 deg. Fah. British thermal unit	1055·79*	0·00094716
39 deg. Fah. British thermal unit	1059·52*	0·00094382
Steam table British thermal unit (1939)	1055·06	0·00094781

(The exact equivalent, in the Fahrenheit scale, of 4 deg. Cent. is 39·2 deg. Fah.)

* The values are not definite to this order of accuracy, but are given to five and six figures for the sake of uniformity.

Table III shows conversion factors for various British thermal units.

Thermal Quantities Affected by the Change of Heat Unit

The thermal quantities affected by this change in the heat unit will be specific heats, latent heats, entropy, internal energy, enthalpy, free energy, Gibbs function, and thermal conductivity.

In highly accurate thermo-chemistry it is now customary to express free energy changes accompanying a chemical reaction and heats of reaction in joules.

Notes on the Various Heat Units

(1) *The International Steam Table Calorie.* Callendar's steam tables (1915) were based on his experiments on the total heat of water by continuous electric calorimetry and mixture methods. He takes the mean gramme-calorie as 4·1868 joules.

The international Steam Table Conferences of 1929, 1930 and 1934 defined the international steam table calorie as the quantity of heat equivalent to 1/860 of an international watt-hour or 3600/860 international watt-second, which, to six significant figures, is 4·18605 international joules. There were several "international joules" in existence. For example, the international volt and ohm as maintained in the National Bureau of Standards differed sufficiently from those at the National Physical Laboratory to make a difference of at least four parts in 100,000 between the respective values of the joule. However, when these differences between national units are disregarded the ratio is, 1 mean international joule§ = 1·00019 absolute joules. This is the appropriate conversion to use and it represents almost exactly the mean of British and American units. The value of the international steam table calorie in absolute joules is then 4·1868. For much calorimetric work, however, it is sufficient to take the figure as 4·187.

(2) *The 15 deg. Calorie.*—The International Union of Pure and Applied Physics at the meeting of the General Assembly of the Union held in London on October 5, 1934, made two recommendations. They were:

(1) That the unit of heat when measured in units of energy be the joule, defined as equivalent to 10^7 ergs, and

(2) That the gramme-calorie be the amount of heat required to raise the temperature of 1g of air-free water from 14·5 deg. to 15·5 deg. Cent. of the international scale of temperature under the pressure of one normal atmosphere.

§ Agreed by the International Committee of Weights and Measures, Paris, October, 1946.

The most recent determination, that of Osborne, Stimson and Ginnings (1939), has given the value 4·1857 absolute joules for the 15 deg. calorie.

British Standard 205 : Part 1 : 1943, defines the gramme-calorie as the quantity of heat required to raise the temperature of 1g of water at 15 deg. Cent. by 1 deg. Cent.

The International Committee of Weights and Measures in 1950, on the advice of the Consultative Committee of Thermometry and Calorimetry (chairman, Professor W. J. de Haas) adopted the value 4·1855 for the 15 deg. calorie, so that it may be assumed that this definition of the 15 deg. calorie will supersede those mentioned above.

(3) *The Thermochemical or "Defined" Calorie.*—This unit has been widely used in the United States when recording thermochemical data. The idea of a "defined" calorie was introduced in Volume 1 of the International Critical Tables, 1926. The tables of accepted constants in that volume listed three calories, including a 15 deg. Calorie, with a footno e which implied that this was defined as 4·185 absolute joules. Rossini (1931), working in the international system of units, derived from the above the value 4·1833 international joules, using the conversion factor 1·0004 as the ratio of the international to the absolute joule, the value considered appropriate about that time—1934. If the modern value for the conversion factor, as adopted by the National Bureau of Standards (N.B.S.) is taken, 1 international joule (N.B.S.) = 1·000165 absolute joules, the thermochemical or defined calorie of Rossini becomes 4·1840 absolute joules.

(4) *The Mean Calorie.*—The mean calorie is taken as one-hundredth of the amount of heat required to warm 1g of water from the melting point to the boiling point.

The work of Osborne, Stimson and Ginnings provides data over an extended range of temperature as to the heat capacity of air-free water at 1 atmosphere pressure. When the N.B.S. factor of 1·000165 for conversion from international to absolute joules instead of 1·00019 quoted in their paper is used, the value 4·1899 absolute joules is obtained for the mean calorie. Reynolds and Moorby (1897), Callendar (1902) and Barnes (1902, 1904 and 1909) covered nearly the full range from 0 deg. to 100 deg. Cent., but the pressure was approximately 1½ atmospheres in the experiments of Reynolds and Moorby. The difference between the results of the various investigations amounts to more than one part in 1000.

The International Committee of Weights and Measures in 1950 adopted a set of values for the heat capacity of water at different temperatures from which the value 4·1897 is obtained for the mean calorie.

(5) *Maximum Density of Water; Large Calorie.*—British Standard 350 : 1944 defines the "large calorie" or kilogramme-calorie as the heat necessary to warm one kilogramme of water, at the temperature of maximum density, by 1 deg. Cent. From Table IV this is 4204·5 absolute joules.

(6) *The Mean Pound-Calorie.*—The pound-calorie was defined by Callendar in the 1915 steam tables as the unit of heat on the foot, pound, Centigrade system. If the value of 4·1897 absolute joules is accepted for the mean calorie then the mean pound-calorie becomes 1·9004 kilojoules.

(7) *The British Thermal Unit.*—(a) *The 60 deg. British Thermal Unit.*—At the present time there are several distinct British thermal units in use. The 60 deg. British thermal unit is the unit defined in British Standard 205 (1926, 1936 and 1943) and the temperature range specified is from 60 deg. to 61 deg. Fah.

To obtain the value of this British thermal unit in terms of the 15 deg. Cent. calorie it is necessary to obtain the ratio of the heat capacity of water at 60·5 deg. Fah. (15·833 deg. Cent.) to that at 15 deg. Cent. The value of this ratio deduced from recent work is 0·99982 so that 1 B.Th.U. becomes 251·95 $cal_{15°}$. If the value of the $cal_{15°}$ is taken as 4·1855 absolute joules, a British thermal unit is equal to 1054·54 absolute joules.

(b) *Mean British Thermal Unit.*—British Standard 205 (1926, 1936 and 1943) defines the mean British thermal unit as 1/180 of the quantity of heat required to raise the temperature of 1 lb of water from 32 deg. to 212 deg. Fah. The value of the mean calorie deduced from the table of the specific heat of water at different temperatures adopted by the International Committee of Weights and Measures is 4·1897 absolute joules. Hence the mean British thermal unit becomes 1055·79 absolute joules.

(c) *Maximum Density of Water British Thermal Unit.*—British Standard 350 : 1944 defines the British thermal unit as the heat necessary to warm 1 lb of water at the temperature of maximum density by 1 deg. Fah.

The International Committee of Weights and Measures calorie at 4 deg. Cent. is 4·2045 absolute joules, which leads to 1059·52 absolute joules as the value of this British thermal unit.

(d) *Steam Table Thermal Unit.*—This British thermal unit is defined in terms of the International steam table calorie—that is, 1 B.Th.U. = 251·996 I.T. calories, where the conversion factor is simply the number of grammes per pound divided by the number of degrees Fahrenheit per degree Celsius (Centigrade). The I.T. calorie was defined as 1/860 international watt-hour by the International Steam Table Conference of 1929.

If the mean international joule is taken as equal to 1·00019 absolute joules, the steam table British thermal unit becomes 1055·06 absolute joules.

Table IV—*Specific Heat of Water in Joules per Degree*

Deg. Cent.	0	1	2	3	4	5	6	7	8	9
0	4·2174	4·2138	4·2104	4·2074	4·2045	4·2019	4·1996	4·1974	4·1954	4·1936
10	4·1919	4·1904	4·1890	4·1877	4·1866	4·1855	4·1846	4·1837	4·1829	4·1822
20	4·1816	4·1810	4·1805	4·1801	4·1797	4·1793	4·1790	4·1787	4·1785	4·1783
30	4·1782	4·1781	4·1780	4·1780	4·1779	4·1779	4·1780	4·1780	4·1781	4·1782
40	4·1783	4·1784	4·1786	4·1788	4·1789	4·1792	4·1794	4·1796	4·1799	4·1801
50	4·1804	4·1807	4·1811	4·1814	4·1817	4·1821	4·1825	4·1829	4·1833	4·1837
60	4·1841	4·1846	4·1850	4·1855	4·1860	4·1865	4·1871	4·1876	4·1882	4·1887
70	4·1893	4·1899	4·1905	4·1912	4·1918	4·1925	4·1932	4·1939	4·1946	4·1954
80	4·1961	4·1969	4·1977	4·1985	4·1994	4·2002	4·2011	4·2020	4·2029	4·2039
90	4·2048	4·2058	4·2068	4·2078	4·2089	4·2100	4·2111	4·2122	4·2133	4·2145
100	4·2157									

The Heat Capacity of Water at Different Temperatures

When thermal data have been given in terms of the heat capacity of water over a range of temperature, Table IV can be used for conversion into absolute joules. It is based on the value 4·1855 for the 15 deg. calorie adopted by the International Committee of Weights and Measures and the variation with temperature of the specific heat of water as given by Osborne, Stimson and Ginnings (1939).

Acknowledgments

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References

Barnes, H. J., 1902 "Phil. Trans.," Roy. Soc. (A), Vol. 199, page 149; 1904 "Trans.," International Electrical Congress, Vol. 1, page 53; 1909 "Proc.," Roy. Soc. (A), Vol. 82, page 390.

Callendar, H. L., 1902 "Phil. Trans.," Roy. Soc. (A), Vol. 199, page 55; 1915 Steam Tables (E. Arnold and Co., London).

Osborne, N. S., Stimson, H. F., and Ginnings, D. C., 1939 National Bureau of Standards *Journal of Research*, Vol. 23, page 197.

Reynolds, O., and Moorby, W. H., 1897 "Phil. Trans.," Roy. Soc. (A), Vol. 190, page 301.

Rossini, F. D., 1931 National Bureau of Standards *Journal of Research*, Vol. 6, page 1.

Steam Shunting Locomotives for Steel Works

We have received from W. G. Bagnall, Ltd., of Stafford, particulars of three 0–6–0 saddle tank locomotives recently completed for the Steel Company of Wales, Ltd., Margam Works. These locomotives were designed and built to the requirements of the Steel Company of Wales, and embody some details which are unusual in industrial locomotives, but which have been incorporated to facilitate maintenance and servicing, and to make the locomotives easy to handle.

The new locomotives, one of which is illustrated on this page, are required to haul seven ladle cars each of 65 tons gross weight, up an incline of 1 in 100, and to traverse curves of 170ft radius. The principal dimensions of each of the locomotives are as follows :—

Cylinders	18in dia. × 26in stroke
Wheels	4ft 3in dia.
Wheel base	11ft
Boiler pressure	180 lb per square inch
Heating surface :	
Firebox	100 square feet
Tubes	855 square feet
Total	955 square feet
Grate area	18·7 square feet
Tractive effort at 85% B.P.,	25,272 lb
Water capacity	1500 gallons
Fuel	2 tons
Weight in working order	52·5 tons
Weight empty	40·5 tons

The engines have main frames 1¼in thick and are fitted with buffer beams 3in thick. The buffer beams extend to within 5in of rail level, and in addition to acting as rail guards and derailing bars, also serve to protect the locomotive from damage which may be caused by material lying too near the track. Heavy buffers are fitted, and the drawbar has a shank 2½in diameter.

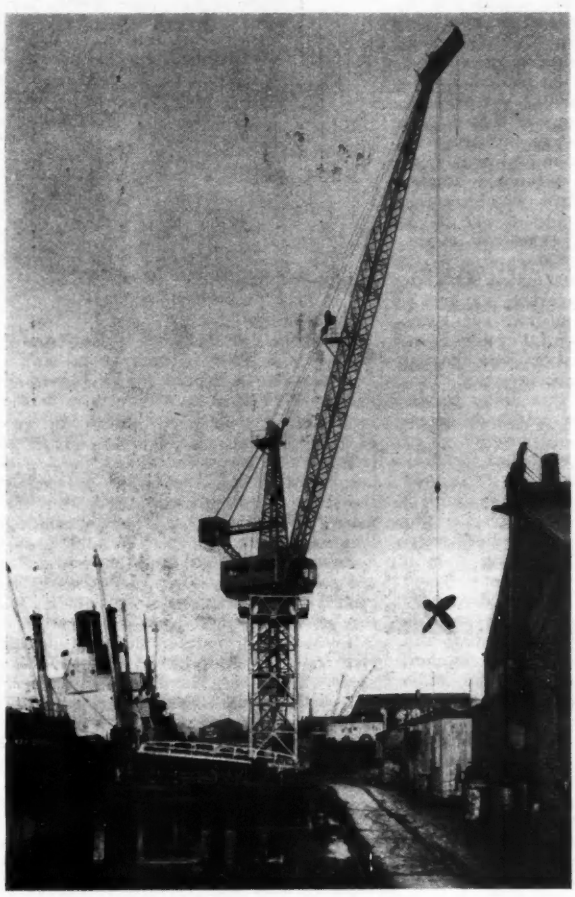
The special features which have been incorporated include single "double-row," self-aligning, roller bearing and cast steel axleboxes supplied by the Skefko Ball Bearing Company, Ltd. These axleboxes are fitted with manganese steel liners which are in contact with liners of the same material fitted to the axlebox guides. As the springs are under-hung the axleboxes have only one guide lip which is on the inside. No arrangements have been made for the lubrication of the manganese surfaces as it is not considered necessary or advisable. The coupling-rods, connecting-rods and eccentric rod big-ends are also fitted with self-aligning roller bearings.

The locomotives have outside cylinders and Walschaerts valve gear, which operates 8in diameter piston valves. The weight of part of the valve rods, lifting links, and die blocks is balanced by counterweights integrally forged on to the reversing shaft arms. This balancing is designed to reduce the force required on the reversing lever and make the driver's job lighter. The slide bars are heat-treated and hardened by the Shorter process on the surfaces in contact with the crossheads.

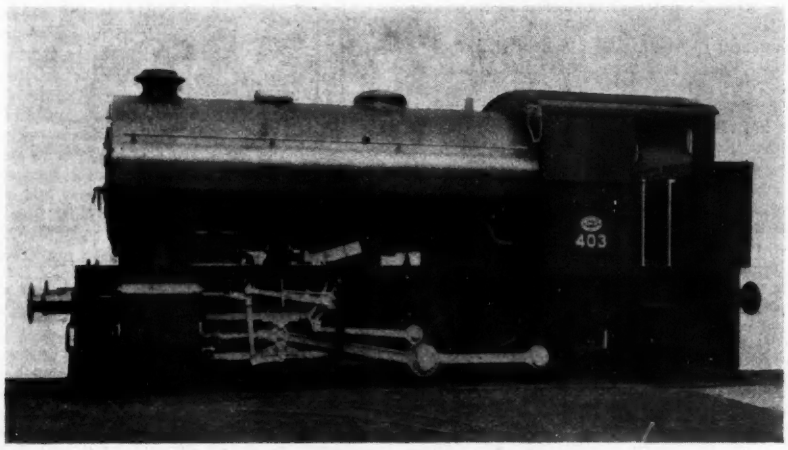
The boiler has a steel firebox and an Owens balanced regulator is fitted in the dome. Cast iron rocking and drop grates are operated by handles in the cab, and are arranged to burn patent fuel in block form. A self-discharging hopper ashpan is fitted with two hopper doors, which are also operated from the cab. Reflex water gauges made by Richard Klinger, Ltd., are provided, and an "Everlasting" blow-off cock, which can be operated by a hand lever from the footplate, is fitted to the front of the firebox. The four steel sandboxes of each engine are fitted with wet sanding apparatus in order to make the supply of sand less difficult, since damp sand can be used.

A circular, self-cleaning smokebox is supported on a fabricated steel saddle, and the front plate is fitted with an asbestos joint ring for the door. The saddle tank, rigidly fixed to the main frames and smokebox, is of all-welded construction throughout.

Steam brakes provided on the engines act on all wheels through double brake blocks, and the steam brake valve can be operated from both sides of the cab.



MONOTOWER CRANE



SADDLE TANK SHUNTING LOCOMOTIVE

Light Alloys in Monotower Crane Construction

We reproduce herewith a photograph of a monotower crane, designed and built for the Tyne Dock Engineering Company, Ltd., at South Shields, by Butters Bros. and Co., Ltd., of Glasgow. The crane is of particular interest, as aluminium alloy sections have been largely used in the construction of its 160ft long jib. The jib is constructed in five sections, the lowest of which is of rolled steel and the other four of aluminium alloy, according to B.S.S. 1161, Group 7.

The steel supporting tower of the crane is 56ft high and is erected on a reinforced concrete foundation. A revolving mast of steel construction is supported on a double-row ball race at the bottom, and a series of horizontal anti-friction rollers running on an internal pressure ring is fitted to the top of the tower.

The jib is 6ft deep and 7ft 3in wide at the centre, tapering to 20in deep at each end. Four equal angles of 6in by 6in sections form the main jib members. The bottom members are ⅜in thick throughout. The top members are ½in thick in the three top sections and in the two bottom sections ⅝in thick. The elevation bracing angles are of 3in by 3in by $\frac{5}{16}$in angle section alloy, and the plan bracing consists of a 3in by 2½in by $\frac{5}{16}$in angle section alloy crossing with a 3in by ⅜in flat alloy section. Diaphragm bracings are fitted, where required.

The jib is riveted throughout with ⅞in diameter steel rivets, and before assembly the rivet holes were primed with zinc chromate-base paint and all scale was subsequently removed. When the jib was completed the structure was thoroughly degreased and an etch primer was applied before the priming coat, followed by the finishing coats.

The new crane has the following capacities and particulars :—

	B.h.p. of motor	Load, tons	Speed, ft/min
Main hoist	55	15	30 (Slow gear)
		5	100 (Fast gear)
Auxiliary hoist	30	2	126
Derricking	60	15	50
Slewing	30	15	300

Capacities	Tons	At a radius, feet
	15	95
	12	108
	10	116
	7	128
	5	138
	4	150
	3	160

A considerable saving in the jib weight was attained by using the light alloy, which caused a corresponding saving in the power required to lift the jib under working conditions.

An Automatic Car Transmission System

AFTER four years of research, the Ford Motor Company, of Detroit, has developed a form of automatic transmission, which is being introduced as optional equipment in place of a standard synchro-mesh drive on the 1951 models of the company. This "Fordomatic" drive is a combination of a hydraulic torque converter and a planetary gear train, which provides three forward speeds and one reverse. From a historical point of view, it is of interest to note that a planetary gear system, operated by foot pedals, was employed many years ago on the Model "T" Ford motor-cars. However, it was abandoned in favour of the sliding gear system in 1928, with the advent of the Model "A." The fact that the new automatic transmission is being applied to a car, which, in the United States, is in the highly competitive "low-priced" field (1600 to 1800 dollars), means that details of design were influenced by an endeavour to keep both the additional cost and weight of the transmission within reasonable limits. Compared with the standard synchro-mesh gearbox, an additional weight of 77 lb is involved and, currently, the extra cost of the automatic transmission is 168 dollars.

A cross-section of the transmission is shown in Fig. 1. The planetary gearbox employs a double pinion gear set having two sun gears and one internal gear. This total of nine gears provides three forward ratios—two geared and one direct—and one reverse ratio. Two multiple disc clutches and two brake bands, which are all hydraulically actuated, determine the path through which power flows in the various gears. The forward disc clutch is engaged in all forward speeds and is disengaged in neutral and reverse. The rear disc clutch is engaged in high and reverse. The forward brake band is engaged in intermediate only, while the rear brake band functions in both low and reverse. Two oil pumps, one driven at all times by the engine and one driven by the output shaft, deliver oil under pressure to charge the torque converter, to actuate and control the brake bands and the disc clutches, and to lubricate the entire mechanism. The control system consists of a pressure regulator assembly, a hydraulic governor mounted on the output shaft and the main hydraulic valve body assembly, in which are centralised all the manual and automatic control functions. The following table shows the epicyclic gear ratios, the torque converter ratios, the overall transmission ratios and the overall drive ratios based on a rear axle ratio of 3·31.

Gear	Epicyclic gear Ratio	Torque Converter Ratio	Overall Transmission Ratio	Overall Drive Ratio
Low	2·44	2·1 (at stall)	5·13 (at stall)	16·98 to 8·08
Intermediate	1·48	2·1 (at stall)	3·11 (at stall)	10·29 to 4·90
High	1·00	1·57 (at 20 m.p.h.)	1·57 (at 20 m.p.h.)	5·20 to 3·31
Reverse	2·00	2·1 (at stall)	4·2 (at stall)	13·90 to 6·62

The torque converter ratio in "high" is shown at 20 m.p.h. as the transmission shifts into "intermediate" at full throttle below this speed.

Power Transmission

Power transmission through the converter and the epicyclic gearbox in forward and reverse ratios is shown diagrammatically in Fig. 2. In "neutral," with the engine idling, both clutches and brake bands are disengaged. The input shaft to the transmission is driven by the engine and, rotating with it, are the forward clutch drum and the drive plates of both the forward and the rear clutches. In low gear the forward clutch is engaged, coupling the input shaft with the forward sun gear. The rear brake band is engaged, preventing rotation of the planet carrier. Drive is then through the long and short pinions as idlers to the internal gear on the output shaft. In intermediate gear, the forward clutch is still engaged and the forward sun gear is coupled to the input shaft of the transmission. Now, however, the forward brake band is engaged, preventing rotation of the large sun gear, and the planet carrier is free to rotate in the same direction as the input shaft but at a lower speed. Once again, the drive is being transmitted from the forward sun gear to the internal gear through the long and short pinions. In high gear, both clutches are engaged and both brake bands are released; therefore, all parts rotate together and a direct drive through the gearbox results. In reverse gear the forward clutch is released and the rear clutch is engaged, so that the large sun gear is coupled to the input shaft. The planet carrier is held against rotation by the rear brake band and the drive is from the large sun gear across the long pinion only to the internal gear, bringing about a reversal in direction of rotation between input and output shafts.

Transmission Control and Operating Characteristics

The driver controls the transmission by means of a selector, which is mounted on the steering column and moves in the plane of the steering wheel. There are five positions indicated: park (P), reverse (R), neutral (N), drive (DR), and low (L). Movement of the selector lever between neutral and drive requires only a short motion. To avoid accidental overtravel of the selector into reverse or low, the mechanism has been designed so that it is necessary to lift the lever toward the steering wheel as it is moved out of the neutral or the drive positions. Movement of the selector to the park position engages a pawl in the teeth, which are on the outside of the internal gear, thus positively locking the driven shaft against rotation.

In the first instance, as it is necessary in this transmission to pass through neutral to reach reverse, the likelihood of accidental shifting into reverse is greatly reduced, and, for this reason, a reverse inhibitor was not considered necessary. Virtually all normal driving conditions are handled adequately in the drive range. In this range, shifting between the intermediate ratio (1·48 to 1) and the high ratio (1 to 1) is effected automatically, in accordance with the performance required. A simple linkage connects a lever on the transmission with the engine throttle control and maintains the desired relationship between engine output torque and transmission ratio.

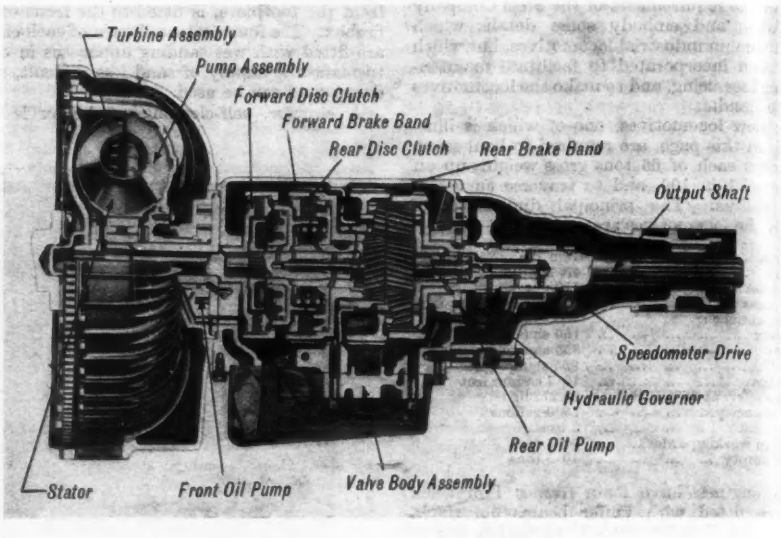


FIG. 1—SECTION THROUGH TRANSMISSION UNIT

The intermediate ratio, amplified by the torque converter ratio of 2·1 to 1 at stall, provides an overall transmission starting ratio of 3·11 to 1, which has been found to satisfy all but the most unusual demands for maximum acceleration, uphill driving or downhill braking. When starting the car with the selector

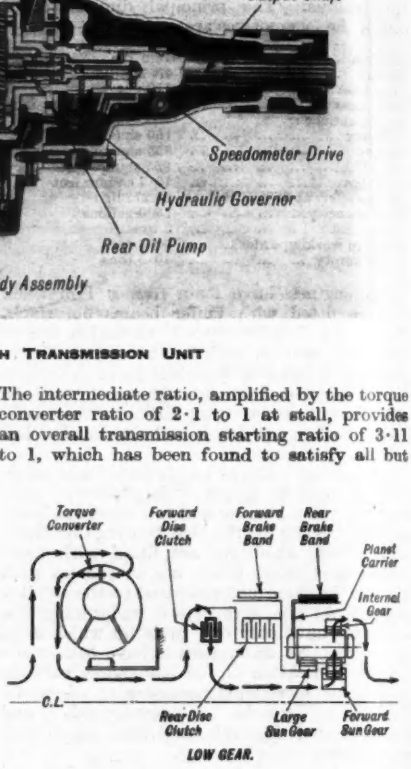


FIG. 2—GEAR FLOW DIAGRAMS

in the drive range, the transmission is always in intermediate and, as shown in Fig. 3, the shift to high is made automatically at speeds between 17 m.p.h. and 63 m.p.h., depending on the degree of engine throttle opening. At speeds below 57 m.p.h. the intermediate ratio is brought into use by pressing the throttle beyond the wide-open position. At speeds below approximately 20 m.p.h. shifting down to intermediate occurs at less than full throttle and, under closed throttle conditions, the automatic shifting down occurs at 5 m.p.h. to 8 m.p.h. To fulfil demands for maximum acceleration, uphill driving or downhill braking, the low range of the transmission is engaged manually by movement of the selector lever to the low position. At speeds below 40 m.p.h. and regardless of throttle opening, the shift to the low range places the transmission in the lowest ratio (2·44 to 1). At speeds above 40 m.p.h., movement of the selector to low shifts the transmission to intermediate, in which gear it remains regardless of throttle opening. Once in the low position, the selector remains there regardless of car speed until a manual shift to the drive position is made. Shifting between low and drive may be accomplished under torque at any throttle opening.

Torque Converter

The more important performance characteristics of the torque converter of the transmission are indicated in Fig. 4. The torque ratio is approximately 2·1 at stall; engine speed rises with vehicle speed, thus permitting a reasonable stall speed, while giving torque conversion to a speed which is sufficiently high (approximately 48 m.p.h.) to provide an adequate converter performance range, and converter efficiency is high above the 0·5 speed ratio, thus improving performance during the considerable amount of driving which has to be done in the higher speed ratios of the converter range. In accordance with conventional practice, the torque converter consists of three basic elements: the pump, the turbine and one stator or reaction member. The pump is driven from the engine through a flexible plate in order to reduce the transfer of vibrations from the engine to the transmission. The cooling of the converter and the transmission oil is accomplished primarily by air circulation through the converter housing. Fins cast on the pump cover serve the dual purpose of providing cooling surface and vanes for the pumping of cooling air. The air is drawn in through an inlet at the lower left side, passes through the converter housing by centrifugal action and is exhausted at the lower right side. Thus, heat transfer is directly through the aluminium pump cover into the air stream.

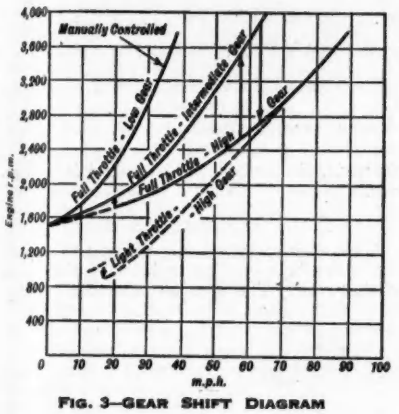


Fig. 3—Gear Shift Diagram

Gearbox

The planetary gear system employs three pairs of long and short pinions, two sun gears and one ring gear. All the gears are made of through-hardened high carbon alloy steel, their diametral pitch is 14 and their helix angle is 20 deg. The two multiple disc clutch assemblies employ alternate sintered bronze and steel plates. The forward clutch, which is engaged in all forward speeds, uses three bronze and two steel plates, providing a total of six friction surfaces. The rear clutch assembly employs four pairs of bronze and steel plates and is engaged in reverse and high gears. Fig. 5 shows a cross-section through the forward brake band and its servo-mechanism. The band assembly employs a single wrap with a woven facing cemented to the steel band. This band, which is engaged in intermediate gear, holds a maximum of approximately 1 engine torque at stall. The servo body, sleeve, piston and actuating lever are all die-cast and the piston, the lever pins and the adjusting screw are the only steel parts involved. The rear brake band, which is required to hold reaction torque in both low and reverse, also employs a single wrap. However, because of the much higher torque loads involved (approximately six times engine torque in reverse), the band is wider and heavier than the forward band and employs a 0·050in thick semi-metallic friction facing cemented to the band.

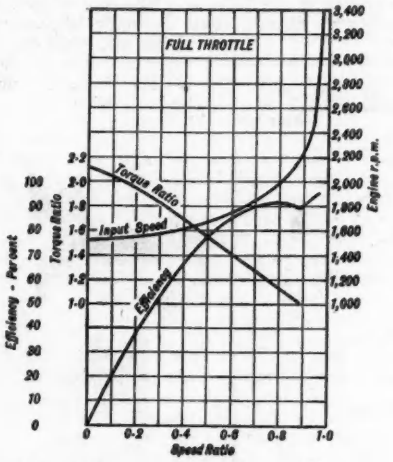


Fig. 4—Torque Converter Performance Characteristics

The operating pressures of both the front and the rear oil pumps vary with operating conditions. The idle and cruising pressure requirements of the control system are approximately 75 lb per square inch. At full throttle stall conditions, the pressure in the drive range is increased to 125 lb per square inch and in low and reverse to 150 lb per square inch. Again, in the drive range at full throttle, the pressure requirements decrease from 125 lb per square inch at stall to the nominal line pressure of 75 lb per square inch, at approximately 35 m.p.h. At relatively low car speeds, the rear pump alone supplies the control requirements and the front pump operating pressure drops to approximately 30 lb per square inch. The centrifugal hydraulic governor is situated on the output shaft of the transmission. It is simple in design and construction as well as in function, with only one hardened steel valve operating in an aluminium die-cast body. Only one pressure curve is developed by the governor and this fulfills all the functions required of the unit, such as the control of the automatic shift points, the modulation of control pressures and the lock-out of the low range at speeds above 40 m.p.h. Apart from the centrifugal governor and a pressure regulator assembly which determines the pressure for both the operating of the transmission controls and the charging of the torque converter, all control functions have been centred in the valve body assembly. For manual control purposes this assembly includes a valve, which is connected through an external linkage, to the steering column transmission control. In addition to the manual valve, there is a valve assembly which, by means of an external linkage to the engine throttle control, regulates a pressure in approximately direct proportion to the opening of the throttle. This pressure serves a dual purpose (see Fig. 3). It acts upon one end of the automatic intermediate-high shift valve, opposing the action of the governor pressure. Thus are obtained the two elements of control, which are required to maintain an optimum shift pattern at any particular instance. The pressure also acts upon what is known as a compensator valve, which modulates the main control pressure to maintain the torque capacity of the clutches and the brake bands in line with the engine output. Furthermore, there is a valve which regulates a low servo pressure needed to soften the engagement of the rear brake band on the shift from drive to low range. Still another valve, known as the low inhibitor, is acted upon by the governor pressure and, at speeds above 40 m.p.h., is positioned so as to prevent the transmission from shifting into low range.

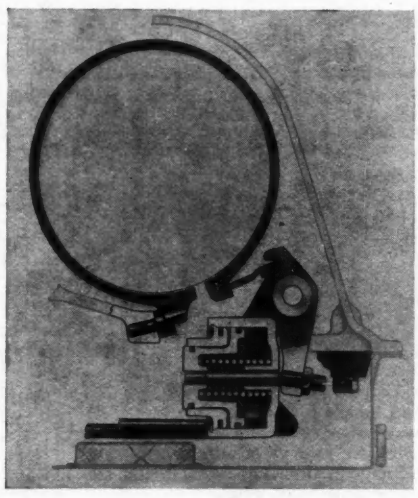


Fig. 5—Section Through Forward Brake Band

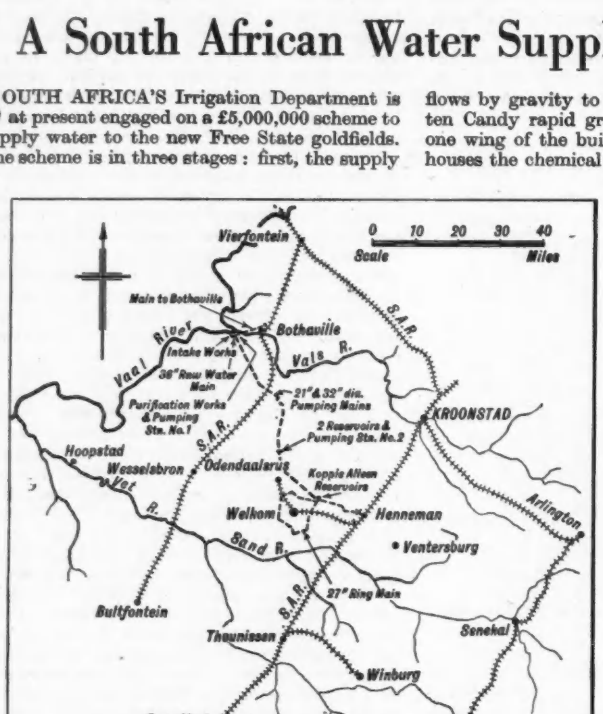
Expansion of Oil-from-Coal Project

Mr. N. C. Havenga, South Africa's Minister of Finance, stated recently that £18,000,000 had been put aside to finance the production of oil from coal. This indicates that the original scope of the Union's scheme has been appreciably enlarged. The capital structure has been increased by nearly 40 per cent and the potential capacity of the plant at Coalbrook has been increased to 60,000,000 gallons of motor spirit and diesel fuel a year, an increase over the original estimate of just over 70 per cent. The production costs of the finished products of the factory are expected to be lower than under the smaller, original scheme. Although the scope of the oil-from-coal project has been increased, however, it will by no means satisfy the whole of the Union's requirements for petrol and diesel fuel, which are now running into the neighbourhood of 320,000,000 gallons of petrol and 100,000,000 gallons of diesel fuel a year. Assuming that the motor spirit yield is in the neighbourhood of 60,000,000 gallons a year, or less than 20 per cent of the Union's demand, the amount of diesel fuel that can be produced will be approximately 9,000,000 gallons or less than 10 per cent of requirements.

It is understood that the contracts for the supply of the main portions of the Coalbrook plant will be placed very soon and, if the negotiations at present in hand are successful, the process to be used will be a combination of the German Fischer-Tropsch Lurgi process and the American process. The increased production of petrol and diesel fuel now envisaged will naturally mean greater mining activity than was originally anticipated at Coalbrook. On the basis that 7 tons of coal are required to produce 1 ton of petrol, the mine at Coalbrook can be estimated to produce over 2,000,000 tons of coal a year and will then be one of the largest coal mines in the Union.

A South African Water Supply Scheme

SOUTH AFRICA'S Irrigation Department is at present engaged on a £5,000,000 scheme to supply water to the new Free State goldfields. The scheme is in three stages: first, the supply of an initial amount of 4 m.g.d.; secondly, the supply of 16 m.g.d. by 1952; and, thirdly, the provision for duplicating this supply, when the growth of the goldfields justifies it, to 32 m.g.d. The second stage, it is estimated, will cost £2,500,000.



THE ODENDAALSRUS WATER SUPPLY PROJECT

When, after the discovery of gold in Odendaalsrus in 1945, the request for a water supply was received from the mining companies there, the Government formed a departmental committee to investigate the matter and this committee recommended that the State should finance and construct a water supply scheme to serve the new goldfields area. Supply from the Sand River, the nearest river to the area, was ruled out since the run-off during poor years was insufficient to meet the demand. The next source of supply was the Vaal River, which, in conjunction with Vaal Dam, could meet the requirements of the goldfields as well as its other commitments. It was accordingly decided to construct pumping stations and purification works on the Vaal River, near its confluence with the Vals River, as shown in the accompanying diagram.

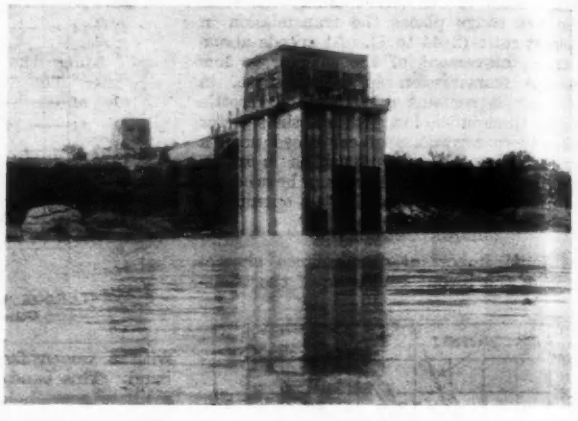
The left bank of the Vaal River at the site of the intake consists of a sandstone cliff, rising some 50ft above water level. From the abutment formed by this cliff, an approach bridge spans across to the combined intake and pumping station, situated in the river itself. The river at this point is some 20ft deep and, due to a rock bar about two miles downstream, it forms a natural pool of considerable capacity. The pumps are below the water level in a dry well in the intake tower. The control deck of the tower is some 50ft above the normal water level, so as to be well clear of floods. The water is pumped from the intake to the adjacent purification site, about 70ft above normal water level, through a 36in concrete-lined steel water main. The illustration below shows the combined raw water intake and pumping station.

The raw water passes through a dosing chamber, where lime and alum are added by dosing machines, to four sets of sedimentation tanks, each capable of dealing with 4 m.g.d. The sedimentation tanks are divided into primary and secondary units, the water being given a further alum dose before passing into the secondary sedimentation tanks. The retention period in each set of tanks is about 7½ hours.

From the sedimentation tanks the water flows by gravity to the filtration block, where ten Candy rapid gravity filters are housed in one wing of the building. The central section houses the chemical feed machines, laboratory, stores and wash-water tanks. The east wing of the building will be built when the full 32 m.g.d. is required and the scheme is duplicated. Each filter, which has an area of 33 square feet, has a capacity of 2 m.g.d. The filters are situated above a clear-water reservoir, which acts as a sump for the adjacent high-lift pumping station. Again, only one wing of the high-lift pumping station is being built initially to handle 16 m.g.d. Workshops, stores, administration buildings, transformer stations, sludge disposal works, houses for personnel, gardens and areas reserved for future extensions, are all provided in the 250 acre site overlooking the river.

Due to the fact that two-stage pumping reduces the thickness of steel for the rising head, thus reducing the amount of steel used, it was decided to provide an intermediate pumping station and to split the head into two parts. The water is therefore pumped first to an intermediate site 30 miles away and 8 miles to the north of Odendaalsrus, and there a pumping station similar to the first boosts it over the next stage to the distribution reservoirs at Koppie Alleen. A reservoir at the intermediate pumping station provides balancing storage for the pumping system. To serve the initial stage of the scheme a 21in diameter pumping main was required. Later, when the 16 m.g.d. supply is in operation, it will be necessary to provide for the installation of a further 32in pumping main.

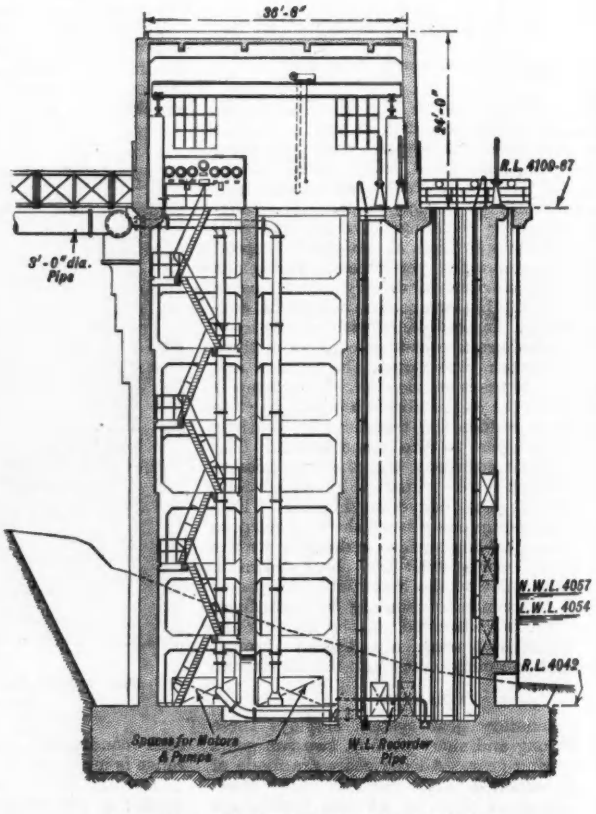
At Koppie Alleen, which forms the only high ground near the goldfields area, four reservoirs each of 6·4 m.g. capacity, are provided to hold 1½ days' supply for the second stage of the scheme. From Koppie Alleen the water is fed by gravity through a ring main of 27in diameter and 25 miles long, to the various mines and townships in the area. Besides the goldfields, the scheme also serves two small towns. Bothaville, which is 9 miles away, is fed by a separate pumping main (8in in diameter) directly from the purification site at Balkfontein, while Henneman, 15 miles from Koppie Alleen, is supplied by a small pumping station and a 9in main, situated at the Koppie Alleen reservoir.



RAW WATER INTAKE TOWER

Construction

A number of interesting construction problems have been encountered during the course of the work. The area is underlain by clays and shales, which create foundation difficulties. Consequently, all important structures have



SECTIONAL ELEVATION OF INTAKE TOWER

their foundations at a considerable depth. At the purification works the main buildings and high-lift station are founded on columns carried down through the sandy clay to soft sandstone 30ft to 40ft below the ground surface. At the intermediate pumping station the reservoir load was spread by limiting the water depth to 12ft 6in and the sandy clay was blanketed with 6ft of compacted, drained gravel under the walls, and 2ft of gravel under the floor. The main pumping station at Balkfontein was carried on columns with splayed footings, on soft shale 35ft below ground surface.

Dewatering the site of the intake structure was another interesting operation. The Department of Irrigation did not possess, at the time, the sheet piling and plant required for this task. A rock and earth cofferdam was ruled out because of the difficulty of removing it afterwards and it was considered possible that a large obstruction might cause the river to alter its course during a high flood. The bed of the river at this point consists of horizontally bedded sandstone some 20ft below the water surface and covered by up to 10ft of sand and silt. Precast concrete piles, 9in thick and 12in wide, were driven along a circular arc 114ft in diameter by a barge-mounted crane. Joints between the piles were sealed and sand and silt removed by a sand pump and water jet. The method proved successful and the total leakage amounted to approximately 10,000 gallons an hour.

More than 500,000 cubic yards of excavation for buildings, reservoirs and pipe-lines are required to complete the 16 m.g.d. stage of the project. Excavation for pipe-lines is being done by chain-bucket trenchers in material varying from sand to hard clay. A variety of excavating plant is employed on excavation for the reservoirs and buildings. More than 45,000 cubic yards of reinforced concrete will be placed in the various structures. All the construction work is being carried out by direct labour by the Department of Irrigation.

Plant and Pipe-lines

The plant at the intake consists of six 10in horizontal centrifugal pumps, direct-coupled to squirrel-cage motors, each 100 b.h.p., the supply being three-phase, 50 c/s, 380V. The pumps are rated to deliver 2800 g.p.m. against a head of 90ft at 1450 r.p.m. Pump efficiency is 85 per cent under these conditions and the power absorbed is 90 b.h.p. Since the head variation is considerable, low water being at R.L.4054 and the maximum flood level R.L. 4107, the pumps are designed for a flat power characteristic, varying from 90 b.h.p. to a maximum of 92 b.h.p. over the delivery range from 2800 g.p.m. to 3840 g.p.m. When in full operation for 16 m.g.d. four of these pumps will operate together, with two as standby units.

The high-lift pump station houses six 10in, two-stage centrifugal pumps, direct-coupled to synchronous motors of 700 b.h.p., the supply being three-phase, 50 c/s and 6·6kV. These pumps are each capable of delivering 2800 g.p.m. against a total head of 591ft, when running at 1500 r.p.m.

Power is obtained from the Electricity Supply Commission's network, through substations at the purification works (88kV), the intermediate pumping station (44kV) and at Koppie Alleen (380V). The 6·6kV supply from the high tension substations is brought to high voltage switchgear consisting of metal-clad, duplicate busbar, switch pillars of the oil and compound type. Their breaking capacity is 150MVA at 6·6kV. Duplicate incoming and outgoing panels, with cables to motor switchboards, are provided from the switch houses.

The pipe-lines of the scheme are of mild steel, wrapped with a bitumen-asbestos compound to resist corrosion. The pipes are laid with about 2½ft of cover so as not to hamper farming operations over the pipe-line route. They are bitumen spun-lined internally, with the exception of the raw water main from the river, which is spun-lined with concrete and the smaller sizes, which are bitumen dipped. The minimum wall thickness is $\frac{5}{16}$in for pipes, which are 21in or less in diameter, and $\frac{1}{4}$in for greater diameters. The thickness varies further with operating pressures, reaching $\frac{7}{16}$in in thickness for the high pressure 32in and 36in mains. The smaller lines are supplied in 32ft lengths and jointed with Johnson couplings. The 36in lines are supplied in 24ft and 32ft lengths and are joined either by couplings or by flange joints.

The pumping main to Koppie Alleen consists of two parallel lines, one of 21in and one of 32in diameter. These two pipe-lines and also the 27in ring main (a total of 113 miles) are being supplied in 32ft lengths and are joined together by field welding into 96ft units before being finally coupled together in the trench.

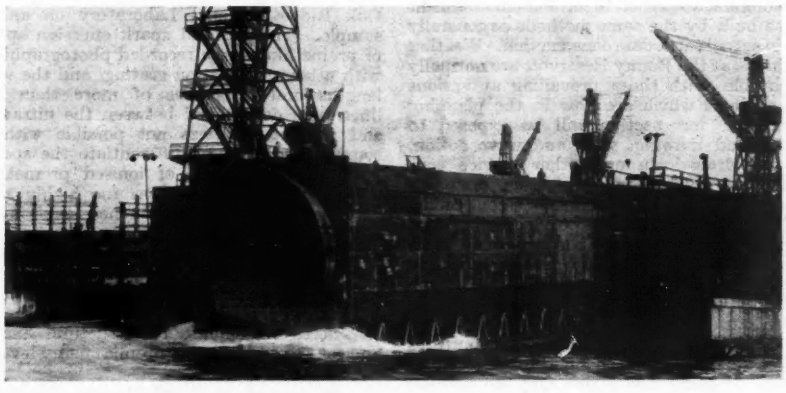
The combined intake and pumping station and sedimentation tanks for 4 m.g.d. were completed at the end of 1950, while the filtration plant was sufficiently far advanced to begin fitting the filtration equipment at that date. The two main pumping stations are now substantially completed, while one reservoir at the intermediate pumping station and one at Koppie Alleen are ready for service. The first pipe-line to Koppie Alleen and the 27in distribution line have been laid and work is proceeding on further units. To assist the mining companies, whose boreholes in the Free State soon proved inadequate, a temporary delivery of settled but unfiltered water has been supplied since the early part of 1950 and about 1 m.g.d. is now being supplied in this manner. It is hoped that the first stage of the project, which will provide 4 m.g.d. of filtered water, will be in operation in a very short time.

American Engineering News

(From our American Correspondent)

A Trench Tunnel Under the Elizabeth River

The first of seven 300ft-long underwater sections of the two-line vehicular tunnel now under construction underneath the Elizabeth River at Norfolk, Virginia, was sunk into position recently. The accompanying engraving shows the launching of one of these sections of double-shelled steel casing at the shipyard of the Bethlehem Steel Company at Sparrows Point, Maryland. The photograph shows the temporary "launching bow," which was fitted to the forward end of the section to ease the pressure exerted upon the flat bulkhead on hitting the water. After launching, the section was towed a distance of 180 miles to the tunnel site, where, while still afloat, it was fitted with an 18in thick interior reinforcing ring of concrete and a section of double-line roadway 22ft wide. Weighted by additional concrete placed between the inner ring and the outer octagonally-shaped shell, the section was then sunk into exact position in a trench 50ft deep by 40ft wide, which had been dredged across the river bottom.



LAUNCHING A TUNNEL SECTION

As further sections go into place, they are bolted together by divers and, in the last phases of construction the joints between individual sections are sealed by heavy rings of concrete poured under water. Finally, the trench is covered with backfill, the bulkheads between sections are holed through, the joints are welded from the inside and the final interior work on the tunnel is completed dry, under water. Each one of the sections for the Elizabeth River tunnel measures 35ft 4in across the width of the octagonally-shaped outer shell and has a weight of 8200 tons. The tunnel will have a length of 3400ft from portal to portal, including a 2100ft long under-water section. It is part of a highway construction project to link the cities of Norfolk and Portsmouth in Virginia, which is scheduled for completion in 1952. Parson, Brinckerhoff, Hall and Macdonald are the consulting engineers and the Merritt-Chapman and Scott Corporation is the contractor on the tunnel project.

Installation of Turbines at Hungry Horse Dam

A contract has now been awarded for the installation of the four 105,000 h.p. turbines and governors and the completion of the power plant and the switching station at Hungry Horse Dam on the Flathead River, near Kalispell, Montana. Under the terms of the contract, the first of the four turbines has to be installed in time for the first 71·25MW generator to go on the line by October, 1952. The water turbines are being manufactured by the Allis-Chalmers Manufacturing Company the electric generators by the General Electric Company and the governors by the Woodward Governor Company.

Employment of Glass Fibres in Prestressed Concrete Construction

Professor Ivan A. Rubinsky, of the American University, Beirut, Lebanon, on the occasion of a recent visit to New York, suggested that glass cords or strands be substituted for conventional steel wires in prestressed concrete construction.* In support of this scheme, he has pointed out the ready availability all over the world of the raw materials required in the manufacture of glass fibres, the relatively small weight of glass reinforcing strands, the almost complete absence of residual strains on account of the lack of plasticity of glass fibres, their high resistance to acidic and basic chemicals, their ability to withstand high temperatures and their low modulus of elasticity, which would tend to prevent loss of prestress due to shrinkage, change in temperature and plastic flow of the concrete. He believes that cords made of glass fibres could be expected to have an ultimate tensile strength in excess of 1,000,000 lb per square inch, which compares with a value of 225,000 lb per square inch for cold-drawn steel wire. Thus, the volume of glass fibre required would be only about a quarter of that of steel wire and would have only

* See also THE ENGINEER, November 25, 1949, page 611, "Prestressed Concrete" by M. E. Freyssinet.

approximately one-fourteenth of the weight of the steel wire. Professor Rubinsky realises the problems which may be caused by such inherent difficulties as the decrease in tensile strength of glass fibres with increase in their diameter; the effect of cracks and irregularities in the fibres; the difference in strength between dry and wet glass fibres, and the unequal distribution of stress amongst the fibres of a strand, but he feels that a replacement of steel by glass offers such important economies, particularly to countries without steelmaking facilities, that further experiments in this field would appear justified.

Pipe-line Transport of Coal

As part of an investigation of the feasibility of a pipe-line for the transport of coal from southern Ohio to the Cleveland area, the Pittsburgh Consolidation Coal Company is constructing a pilot pipe-line at the site of its Georgetown surface mining operations near Cadiz, Ohio. The line will be 17,000ft long and will consist of 12in diameter pipe. The line is expected to be in operation this summer and its cost has been estimated at 550,000 dollars. For pipeline transport purposes, the coal will be ground to small sizes and will be mixed with water. To prevent pump-blade erosion, the resulting slurry will not be run through the pumps along the line. Instead, propulsion will result from additional water forced into the line by compressor pumps built alongside the line. It is believed that, on a large scale, the pipe-line system would be able to cut coal transport costs by as much as one dollar per ton and that, operating continuously, such a line would be capable of handling several thousand tons of coal daily.

Testing Slope-Protecting Materials for Earth Dams

After two years of laboratory experiments, the branch of design and construction of the Bureau of Reclamation at Denver, Colorado, is now ready to begin prototype testing of asphaltic concrete and soil cement as substitute materials for the riprap commonly employed on earth dams. Under a contract awarded to the North-Western Engineering Company of Denver, a test earth embankment at the Bonny Reservoir in eastern Colorado is to be constructed as a means of evaluating the durability of asphaltic concrete and soil cement as slope-protecting materials. The test embankment section is to be built on the reservoir shore, about two-thirds of a mile upstream from the dam. It will be about 400ft long and about 25ft high. The embankment will be built by the same methods as generally used in actual earth dam construction. Weather conditions at the Bonny Reservoir are normally comparable with those prevailing at various sites of dams which are now in the planning stage. The test section will be exposed to freezing and thawing, wind and wave action, reservoir draw-down and other service conditions, to which slope protection materials are subjected. A 3ft-thick soil-cement facing on the upstream slope will be placed for 200ft on the test structure. On the remaining 200ft asphaltic concrete is to be placed in thicknesses varying from 6in to 18in. Although laboratory tests have already established the best mixtures of soil and cement and of soil and asphalt, the prototype ratio of mixtures has yet to be determined on the test section. Because of economies which may be realised from the use of the substitute materials in place of riprap, which is hauled from distant sources, the Bureau of Reclamation estimates that several million dollars may be saved on future earth dams in the Missouri Basin.

Confirmation of the Elements Technetium and Promethium

Recent spectroscopic investigations by W. F. Meggers, B. F. Scribner and W. R. Bozman of the National Bureau of Standards, Washington, D.C., have given positive identification of two new artificial elements. Not so far found in nature, the elements—known as technetium (Tc) and promethium (Pm)—are by-products of uranium fission and were supplied by the Atomic Energy Commission. Studies at the Bureau of the first optical spectra of these elements have revealed by analysis and interpretation many properties of the atoms and of their nuclei. They have also provided reliable wavelengths and intensity data for about 5000 new spectral lines, the strongest of which are stated to be at least one thousand times more sensitive than their X-ray spectra. In the past many of the chemical and physical properties of these elements were predicted on account of their position in the periodic table and this, in turn, led to numerous unsuccessful attempts at discovery. After the discovery of artificial radioactivity in 1934 it became theoretically possible to manufacture the elements by transmutation of others. Element 43 was indeed first produced technically in 1937 by neutron bombardment of molybdenum 42, and it was named technetium. However, even with the largest cyclotrons, the transmutation yield is very small. With the construction and operation of chain-reacting uranium piles in 1942 an entirely new and considerably more efficient method of making the missing elements became available. When uranium undergoes fission, 6·2 per cent of the atomic fragments become atomic number 43 (technetium) and 2·6 per cent become atomic number 61(promethium). In 1949 the National Bureau of Standards received from the Oak Ridge National Laboratory several milligrammes of each of these fission products for the purpose of making reliable descriptions and analyses of the spectra characteristics of these artificial elements. A total of 4 milligrammes of highly pure technetium was used to photograph the arc and spark emission spectra with a large diffraction grating. The spectra were recorded several times from the ultraviolet to the near infra red, and between these limits the wavelengths and the relative intensities of about 2300 radiations characteristic of technetium atoms and ions were determined. By comparing intensities in arc and spark excitation, the lines could be definitely assigned either to neutral atoms or to singly ionised atoms. In the course of the investigation of the absorption and emission spectra of promethium, the rare earth character of this sample was immediately disclosed by strong bands in its absorption spectrum and by an extremely complex emission spectrum when excited by electric arcs or sparks. The principal absorption bands were observed to have wavelengths of 494·5, 548·5, 568·0, 685·5 and 735·5 millimicrons, showing excellent agreement with earlier measurements made by the Oak Ridge National Laboratory on another sample. The arc and spark emission spectra of promethium were recorded photographically with a large diffraction grating, and the wavelengths and intensities of more than 2200 lines were determined between the ultraviolet and the red. It was not possible with the sources employed to differentiate the spectral lines of neutral and of ionised promethium atoms and the sample was too highly radioactive to recover for further experiments. Consequently, the preliminary description of the emission spectrum of promethium, although it confirms the discovery of the rare earth and provides a sensitive test for future identification of the element, must at present be considered inadequate for structural analysis and for the derivation of atomic energy levels.

Production of Diesel-Electric Locomotives

Following an agreement between the Electromotive Division of the General Motors Corporation of La Grange, Illinois, and the Clyde Industries, of Sydney, New South Wales, the assembly of American diesel-electric locomotive components is to begin shortly in Australia. Engine and power transmission equipment will be manufactured at the La Grange works of the Electromotive Division and will be sent to Australia for assembly in locomotives to be built by the Clyde Industries. Initial orders cover twenty-eight locomotives for the Australian State Railways and the first one of these is expected to be in operation before the end of the year.

French Engineering News

(From our French Correspondent)

Airport construction in the Paris area in 1950 included work on the enlargement of Orly airport, from an area of 800 hectares to 1800 hectares. The work is not completed and a tunnel is being built to carry an existing motorway underneath the airport extension. A secondary road will also be constructed to branch off from the motorway and serve the aerodrome. The development of the motorway is also envisaged to improve the road journey from Paris to the airport.

It has been decided that when these extensions have been completed Orly will handle all passenger services and Le Bourget all air freight. At the moment Orly takes all extra-European traffic and the European airlines make use of Le Bourget.

* * *

During last year French shipbuilders constructed 200,000 tons of shipping and repaired 45,000 tons. Some 450,000 tons of shipping are under construction at the present time, the total French merchant marine being 3,080,555 tons.

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The electrification of French West Africa is to be developed with the construction of a diesel-electric power station comprising four 110kW sets at Ouagadougou. Work has already been started and it is expected that the plant will be ready by April, 1952. Street lighting will then be installed in the district for the first time. The transmission system, which will include 5½km of high-tension cable and 18½km of low-tension, will not be completed before November, 1952.

The construction of a similar generating station at Bobo-Dioulasso is also envisaged, where three diesel sets, two of 140kW and one of 200kW will be installed. The high-tension network will cover 10km, and a special 14km line will feed a pumping station at Dinderesso.

* * *

The hydraulic laboratory for the Dauphiné, whose primary task is to study the characteristics of the rivers in that region, has recently constructed a hydraulic model 125m long and 20m wide. The large size of the model is said to aid considerably the researches which are being carried out.

The laboratory is at present studying the estuary of the Rance, where research is in progress on a project for the utilisation of tidal power. It is thought that the cost of building such a plant would be no more per kilowatt than that of a conventional hydro-electric scheme.

* * *

On June 1, 1951, the first of ninety locomotives ordered by Brazil will leave French workshops. These locomotives have been designed for Brazilian conditions, the country only possessing wood or poor quality coal.

Another success for French industry is the installation of an oil refinery at Cubatao, Brazil, which is the first example of France being asked to construct a complete refinery, with cracking, topping and polymerisation plant. The plant will treat 45,000 barrels, or 6000 tons, of crude oil daily.

Finally, in October, 1951, the sugar refining plant constructed by French firms for Uruguay will come into service. It will be capable of treating 1200 tons of canes daily.

Altogether, French mechanical industries have made continued progress in the export markets. Sales abroad increased from 76,000 tons in 1947 to 140,910 tons in 1949 and 246,710 tons in 1950. In the same period, exports to the French Union increased by 100 per cent.

* * *

A Bill for the furtherance of geological, geophysical and mining research has been introduced by the Government. It is proposed that credits would be included in the Budget as a subsidy for a new research organisation, which would also benefit from profits accruing as a result of the exploitation of minerals for which t prospected.

Industrial and Labour Notes

Iron and Steel Supplies

In a written Parliamentary reply at the end of last week, the Minister of Supply, Mr. G. R. Strauss, stated that because of the defence programme and the need to maintain essential production, it would not be possible to satisfy all demands for steel this year. The Government had, therefore, decided to reduce exports of steel and also restrict deliveries to the home market. Licensing control, the Minister announced, would be extended to exports of semi-finished steel, pig iron and alloy steel as from April 16th, and to all other descriptions of steel as from May 14th. Deliveries of steel to the home market would generally be somewhat less than last year, although, of course, there would be exceptions.

The reply went on to say that the Government was examining possible arrangements for controlling the distribution of steel in the home market, in case that became necessary. Industry would be consulted before any detailed scheme was introduced. The Minister also intimated in his reply that he proposed to make a full statement shortly about raw materials for steelmaking, which were appreciably below requirements. He emphasised that intense efforts to collect home scrap would be necessary to minimise the reduction in steel output.

Employment of Elderly People

On Friday last, the House of Commons discussed a private member's motion, submitted by Mr. J. R. Bevins, dealing with the retention in employment of middle-aged and elderly people. The terms of the motion were "that, having regard to the ageing character of the population and the economic and social desirability of deriving the maximum benefit from manpower, especially in view of the demands of the defence programme, this House is of the opinion that active steps should be taken by H.M. Government to encourage the retention of the middle-aged and elderly in employment."

In the course of the debate the Parliamentary Secretary to the Ministry of Labour, Mr. F. Lee, said that the matter was not one merely for the Government but was one for employers and workers themselves. Mr. Lee then proceeded to suggest some "practical ways" in which employers might help. He recommended employers to see that their policy encouraged the retention of all persons able and willing to continue in work, irrespective of age, and to see that no bar was placed on the engagement of older persons, who were fit and willing to work; to see that that policy was understood and practised by personnel managers, works managers and people responsible for day-to-day decisions about engaging and retaining staff, and to make special arrangements, where necessary, for old people to carry on working. This last recommendation, Mr. Lee said, might mean the transfer of those who could no longer maintain the pace to departments where their experience could be of use. He also urged that employers should review, in consultation with the trade unions concerned, any agreements or practices which required retirement at fixed ages, irrespective of other circumstances.

To trade unions and workers, Mr. Lee appealed for a full realisation of the changed circumstances of the present, and asked for their co-operation in encouraging and facilitating the employment of older people. He suggested that the attitude of older people towards retiring at sixty or sixty-five or to remaining at work was coloured quite a lot by what the younger people thought about it when promotion was involved. The change of attitude then, Mr. Lee commented, was not merely a question for the man who was approaching retirement, but for the people still in middle age, who, he thought, should exercise some imagination about what they would feel when they approached the age of retirement and might wish to stay at work.

The Federation of British Industries

At the annual meeting of the Federation of British Industries, which was held in London on Wednesday of last week, Sir Archibald Forbes, deputy-president, was elected president, in succession to Sir Robert Sinclair, who has been in office for the last two years. Sir Archibald, who is an executive director of Spillers, Ltd., and chairman of the Debenture Corporation, was chairman of the Iron and Steel Board from its inception in 1946 until its dissolution in 1949.

Speaking at the meeting, the retiring president, Sir Robert Sinclair, said that this country was suffering under a load of taxation, which stultified initiative and enterprise and added to inflationary pressure. One aspect which directly and seriously affected industry was the difficulty created for adequate provision for replacement costs. It was surely elementary, Sir Robert claimed, that industry should be able to provide the capital for the maintenance of its business wholly, or at least mainly, from its own resources, and should normally look to outside capital for the financing of new enterprises and, to some extent, for expansion as well. When, as at present, sums put to reserve were subject not only to a high rate of income tax but to profits tax as well, and when replacement costs were increasing, the effect of taxation in its present form was very much that of a levy on industrial capital.

Iron Ore Supply Prospects

The iron ore working group of the United Nations Economic Commission for Europe has recently concluded a meeting, in Geneva, which was attended by representatives of nine European countries, and of the U.S.A. From information provided during the discussions, it was estimated that, in 1953, European countries might face an overall shortage of between 5,000,000 and 10,000,000 tons of the ore needed to reach the production target of 59,000,000 tons of pig iron. In arriving at this estimate, the delegates reviewed supply prospects for 1953 of coke and scrap, the conclusion being reached that, on present evidence, coke was not likely in that year to be a factor which would hold up pig iron production.

At the meeting, a detailed report was submitted on iron ore production possibilities, according to the various grades and deposits, in the French economic area. The United Kingdom, Germany, Sweden and Norway agreed to provide similar reports on their production possibilities. It was decided that countries should forward to the secretariat of the Economic Commission for Europe a detailed balance sheet of their 1953 iron requirements and "prospective availabilities" of the iron-bearing materials used in blast-furnaces. A proposal put forward by one ore-exporting country was that long-term contracts should be made which would give mine-owners adequate guarantees in respect of orders and thereby enable them to ensure the necessary investments for increased production. It was stated during the meeting that the main ore importing countries were generally in favour of the principle of such long-term contracts.

Accounting for Management

A booklet entitled "Accounting for Management," which has been written specially for works supervisors, has just been published by the training department of Tube Investments, Ltd., Oldbury, Birmingham. It is being distributed to all grades of supervisors throughout the T.I. group's subsidiaries, so that they may gain a general idea, if not an expert knowledge, of how both manufacturing and trading efficiency can be achieved through cost accounting.

Without going into too much technical detail, the booklet deals with such matters as the need for and uses of costing; division of a works into departments for costing purposes; the routine of costing; costing techniques and cost control. It emphasises that the works supervisor should understand both the objective of cost accounting, and have a general idea of the method by which that objective is reached, so that he can co-operate intelligently in providing the necessary facts.

Employment and Unemployment

The Ministry of Labour has stated this week that during February the working population of Great Britain increased by 12,000 (6000 men and 6000 women), bringing the total at the end of the month to 23,261,000 (15,949,000 men and 7,312,000 women). The size of H.M. Forces increased in February to 793,000, and there were 22,180,000 people in civil employment, compared with 22,166,000 at the end of January.

In the basic industries of the country, 4,156,000 people were at work at the end of February, the only notable increase in these industries during the month being in coal mining, which added 5000 to its manpower. In the manufacturing industries, there was an addition during February of 11,000, bringing the total employed at the end of the month to 8,670,000. In this group, the metals, engineering and vehicles trades were employing 4,115,000 people, compared with 4,109,000 at the end of January.

The latest unemployment returns relate to March 12th, on which day 274,861 people were registered as out of work, compared with 301,952 on February 12th.

The Selection and Training of Foremen

The third national conference of the Institution of Works Managers was held at Southport last week-end and the papers presented for discussion included one by Mr. F. J. Burns Morton on "The Selection and Training of Foremen." The problem that faced industry to-day, Mr. Burns Morton said, was the recruitment, selection and training of prospective supervisors and the development of existing foremen.

Foremen of the future, he thought, should have a better general education, more precise technical training, special instruction in supervision and, above all, training before appointment. For training younger supervisors, use could be made of technical colleges, formal lectures, text-books and periods of training and practice in various departments as assistant foremen. Mr. Burns Morton suggested, however, that the training of older foremen could best be accomplished through the conference method, taking concrete problems as distinct from general principles. He also said that, in order to obtain and retain an effective group of foremen, it was necessary to accept them as part of the management team, to make sure that their status was improved and recognised, and to be certain that they were supplied with adequate information for the proper control of their departments. The foreman, Mr. Burns Morton claimed, should have the personal support of management to enable him to use his influence effectively under conditions of full employment.

Notes and Memoranda

Rail and Road

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—A party of members of the Institute of Road Transport Engineers will leave London on Sunday, April 22nd, for a tour of transport and engineering installations in the Paris region. The tour will occupy a week and the party will be led by Mr. G. Mackenzie Junner, M.I.Mech.E., President of the Institute.

Air and Water

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—At the general meeting of the North-East Coast Institution of Engineers and Shipbuilders, it was announced that Sir Philip B. Johnson was re-elected as President and that Professor L. C. Burrill and Mr. W. H. Purdie were elected Vice-Presidents.

CIVIL AVIATION APPOINTMENTS.—The Ministry of Civil Aviation announces the appointment of Mr. A. H. Wilson, C.B., C.B.E., Under Secretary, to take charge of the Air Services Division in succession to Mr. L. J. Dunnett, C.M.G., who is being seconded to the Ministry of Supply. Mr. T. F. Bird, Head of Economics and Intelligence, has been promoted Under Secretary in charge of Aerodrome Services in place of Mr. Wilson.

THE RESEARCH SHIP "DISCOVERY II."—The Admiralty has stated that the Royal Research Ship "Discovery II" will shortly leave on a voyage which will include the circumnavigation of the South Polar region. She is expected to return to this country about the middle of December. Data will be collected on the distribution of water layers at the Antarctic convergence and the seasonal positions of the convergences and pack-ice edge. Throughout the voyage, records of surface temperature will be kept and studies will be made of the echo-reflecting layers in the water.

SUEZ CANAL TRAFFIC.—The bulletin of the Suez Canal Company states that the volume of traffic which passed through the canal in 1950 totalled 81,796,000 net tons, involving 11,751 transit passages and 72,609,000 tons of cargo. These are record figures and are 18·8 per cent above those for 1949. The average tonnage per passage rose from 6609 tons in 1949 to 6961 tons, while the average tanker tonnage was 7720 tons. The proportion of tanker tonnage using the canal amounted to 63·7 per cent, compared with 58·4 per cent in the previous year. With regard to flag participation, Great Britain supplied the largest volume of shipping, which equalled 32·5 per cent of the total. The bulletin analyses the various types of merchandise, comments on the trends and gives figures for the tonnage in ballast, 27,360,000 net tons, which included 26,432,000 tanker net tons, and the number of passengers, which reached a total of 664,284 and included 253,372 military personnel.

Miscellanea

RAW MATERIAL SURVEYS.—The Purchasing Officers' Association, 146A, Queen Victoria Street, London, E.C.4, has just published two further booklets in its raw material survey series. They are "Chemicals and Fertilisers," by F. Richard King, and "Raw Materials of the Refractories Industry," by R. J. Mitchell. The prices of the booklets are 3s. 6d. and 2s. 6d. respectively.

"MODERN BUILDING" EXHIBITION IN CHESTER.—The Ministry of Works, in association with the building industry, is to stage a "Modern Building" exhibition at Little Roodee, Chester, June 22nd to 30th. The exhibition will cover an area of 200,000 square feet. One section will be devoted to powered hand tools and there will be a comprehensive display of mechanical aids to building.

THE ENGINEERING SCHOOL OF GHENT.—The seventy-fifth anniversary of the Association of Engineers from the Engineering School of Ghent is to be celebrated from September 8th to 13th next. The programme of events includes an exhibition designed to illustrate the most outstanding engineering achievements in Belgium during the lifetime of the Association.

INDUSTRIAL CO-PARTNERSHIP ASSOCIATION.—The Industrial Co-Partnership Association is holding a buffet luncheon at the Royal Empire Society, Northumberland Avenue, London, W.C.2, on Tuesday next, April 24th, at 12.30 p.m. Following the luncheon, Captain Mark Hewitson, M.P., of the National Union of General and Municipal Workers, will speak on "Industrial Relations."

INDUSTRIAL RADIOLOGY.—The Institute of Physics announces that the summer meeting of the Industrial Radiology Group will take place at 47, Belgrave Square, London, S.W.1, from Monday, July 23rd, to Wednesday, July 25th, in the week following the International Welding Congress. Further particulars may be obtained from the honorary secretary of the Group, Mr. B. N. Clack, Radiochemical Centre, Amersham, Bucks.

NATIONAL COLLEGE OF HOROLOGY.—The Minister of Education has appointed Sir Harold Spencer Jones, the Astronomer Royal, to be chairman of the National College of Horology and Instrument Technology in place of the late Sir Allan Gordon Smith. Sir Harold, who was formerly vice-chairman, is succeeded in this office by Mr. D. W. Barrett, chairman of the British Clock and Watch Manufacturers' Association, and general manager of Smiths' English Clocks, Ltd.

INSTITUTION OF WORKS MANAGERS.—The Institution of Works Managers has recently published a new directory of its members. It gives details of the positions held by members, whose names are arranged alphabetically. The last directory was issued four years ago, since when the merger between the Institution of Factory Managers and the Institution of Works Managers has been consolidated. Copies can be obtained from the offices of the Institution at 67–8, Chandos Place, London, W.C.2, at 10s. 6d. each.

JAMES WATT INTERNATIONAL MEDAL.—The 1951 James Watt International Medal is to be presented to Dr. H. H. Blache, of Denmark, at a general meeting of the Institution of Mechanical Engineers at Storey's Gate, London, S.W.1, at 5.30 p.m. on Friday, May 4th. It is expected that the Danish Ambassador, Count Eduard Reventlow, will attend. After the presentation Dr. Blache will deliver a James Clayton Lecture entitled "Stages in the Design of the Large Burmeister and Wain Marine Diesel Engine."

A FILM ON STEEL CASTINGS.—A film has been produced by the Big Six Film Unit, of Endell Street, London, showing the manufacture of steel castings at the works of F. H. Lloyd and Co., Ltd., of James Bridge Steel Works, Staffordshire. The film also records the use of steel castings in the products of some twelve organisations which the firm supplies. Dumpers, road rollers, locomotives and mobile forging manipulators were amongst the articles shown in production and operation. Of particular interest was the production at the works of Ruston-Bucyrus, Ltd., of the 72½-ton excavator where the framework and equipment is mostly formed of steel castings. Sound tracks for this film are being made in several languages and world-wide distribution is planned.

ASLIB ACTIVITIES.—An index of translations held in this country and the other principal countries of the British Commonwealth is being established by Aslib (Association of Special Libraries and Information Bureaux), and it is hoped that it will be available for reference before the middle of the year. The Association's twenty-sixth annual conference is to be held at Ashorne Hill, near Leamington Spa, from Friday to Monday, October 5th to 8th. The programme will include such subjects as the training and organisation of library staff; what can be learned from industrial efficiency methods such as job analysis and time and motion study; and practical bibliographical and documentary projects in operation in the international field, with special reference to Unesco's part in them.

PRESERVATION OF STEAM TRACTION ENGINES.—We have received some particulars of the Steam Traction Engine Preservation Association which has been formed, at Thetford, Norfolk, "to acquire, renovate, operate, exhibit and preserve steam traction engines and other historic machinery." This Association is now making arrangements to stage an exhibition of steam traction and model engines at Thetford during the Festival of Britain, and would welcome, as a gift or loan, equipment or photographs which might be included. The exhibition is intended to commemorate the achievements of all manufacturers of steam road engines, and of the firm of Charles Burrell and Sons, Ltd., Thetford, in particular. The Association proposes to place on the wall of the works formerly occupied by Burrell's a plaque indicating that the first successful heavy haulage steam road engine was produced there in 1856. The honorary secretary of the Association is Mr. A. T. Phœnix, 15–17, The Square, Pike Lane, Thetford. Information about the Association can readily be obtained from him or from Mr. Ronald H. Clark, A.M.I.Mech.E., 50, Mount Pleasant, Norwich. They will also welcome material suitable for preservation and exhibition and any other offers of assistance.

DIPLOMAS IN MANAGEMENT STUDIES.—The British Institute of Management has published a handbook of courses and examinations for the National Scheme for Certificates and Diplomas in Management Studies. It is intended to be of use both for those who provide the courses and for students. The handbook describes the growth and development of the certificate and proposed diploma schemes, and the committee organisation. It also contains guide syllabuses, reading lists, details of participating professional bodies, and a list of regional advisory councils, technical teaching institutions and colleges approved to date for the Common Intermediate Certificate. The handbook, which costs 6s. 3d., can be obtained from the Institute, Management House, 8, Hill Street London, W.1.

Personal and Business

MR. WALTER T. F. HASSAN, A.M.I.Mech.E., has been elected a director of Coventry Climax Engines, Ltd.

MR. F. L. PARKIN, M.I.E.E., A.M.I.Mech.E., has been appointed general manager of Aerex, Ltd., Rutland Park, Sheffield.

B. O. MORRIS, Ltd., Coventry, announces the appointment of Mr. H. S. Royce as director and general manager, and of Mr. M. B. E. Masters as sales director.

NEWMAN INDUSTRIES, Ltd., electric division, has appointed Mr. H. McConchie to be manager of the new branch office at Russell Chambers, 54, Merrion Street, Leeds.

STORDY ENGINEERING, Ltd., announces that it has now moved to bigger premises at Cumbria House, Goldthorn Hill, Wolverhampton (telephone, Wolverhampton 37341).

MR. KENNETH MORRISON, until recently general manager of Penman and Co., Ltd., Glasgow, has been appointed technical manager of Shaw-Petrie, Ltd., Hillington, Glasgow.

THE President of the Board of Trade has reappointed Dr. R. S. Edwards as chairman of the Council of Industrial Design. Mr. A. N. Silver has been appointed a member of the Council.

MR. L. A. NEWBERY, M.A., has joined the staff of Matthew Hall and Co., Ltd., 26–28, Dorset Square, N.W.1. Matthew Hall (Pty.), Ltd., has acquired a factory—the third in the Union of South Africa—at Williams Road, Durban.

MR. BERNARD ADKINS, M.A., M.I.E.E., of the consulting engineering staff of the British Thomson-Houston Company, Ltd., Rugby, has been appointed to the University of London Readership in Electrical Engineering at the Imperial College of Science and Technology.

B.S.A. TOOLS, Ltd., has purchased the entire plant and taken over the work of Machine Tools (Letchworth), Ltd., Stewart Works, Letchworth, Herts. Mr. J. E. Rogers has been appointed works manager of B.S.A. Tools, Ltd., Letchworth branch. The B.S.A. group has also appointed Mr. F. J. G. Petzoldt to be operation research engineer.

THE RAILWAY EXECUTIVE announces the following appointments:—Mr. J. L. Harrington, M.Inst.T., chief officer (marine and administration), Railway Executive headquarters; Mr. A. Dean, M.I.C.E., civil engineer, North-Eastern Region, York; Captain J. D. Reed, A.I.N.A., executive officer (marine), Railway Executive headquarters.

THE UNION-CASTLE LINE announces the retirement of Mr. S. G. West from the post of naval architect. Mr. West, who has completed forty-five years' service with the company, took over the duties of naval architect in 1927 and will be succeeded in that position by Mr. J. A. H. Lees, who has been assistant naval architect since 1945.

MR. FRANK LONSDALE has resigned his position as general manager of Fraser and Chalmers Engineering Works of the General Electric Company, Ltd., Erith, owing to ill-health. Mr. Lonsdale, who joined the company in 1909, has been a director of the General Electric Company, Ltd., since 1946. He will remain on the board and will continue to act in an advisory capacity at Erith.

MR. H. V. POTTER, F.R.I.C., M.I.Chem.E., chairman and managing director of Bakelite, Ltd., has been elected chairman of the Association of Chemical and Allied Employers. Mr. E. P. Hudson, director of Scottish Agricultural Industries, Ltd., has been elected vice-chairman of the Association, and Mr. F. J. Robinson, M.I.Chem.E., has been re-elected vice-chairman of the plastics group.

British Patent Specifications

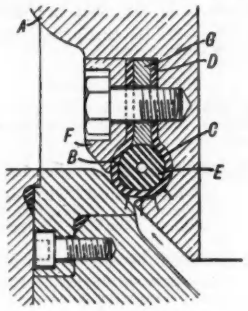
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

VALVES

651,114. November 25, 1948.—ROTARY SPHERICAL VALVES, Boving and Co., Ltd., William Darling and William Kennelly, all of 56, Kingsway, London, W.C.2.

The object of the invention is to provide liquid-tightening means whereby, when the rotor of a rotary spherical valve is in the closed position, the closure will be automatically rendered liquid-tight by the liquid at the upstream side pressing directly against the tightening means. For this purpose around a closure face of the rotor or of the casing of a rotary spherical valve, a stout elastically distortable ring is secured against entry of pressure liquid between the face and the ring, with so small a clearance that lateral distortion of the ring under the pressure of the obturated liquid closes the clearance when the valve is closed. The drawing is a sectional view of a portion of the rotor of the valve and casing, showing the liquid-tightening ring mounted on the valve rotor on the



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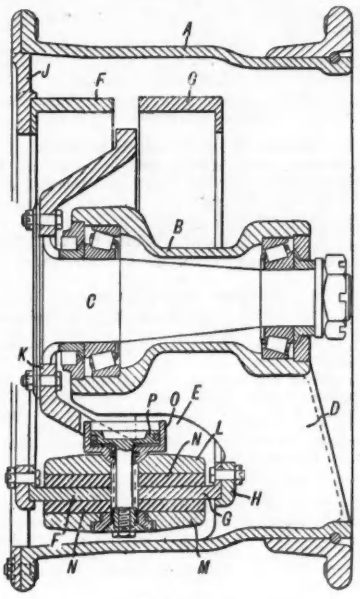
downstream side, with the ring laterally distorted by the pressure of liquid. *A* is the rotor of the valve. The liquid-tightening means consists of a stout rubber ring *B* held in a groove *C* in one closure face and projecting with a minimum clearance towards the opposed closure face, so that under the water pressure the ring becomes laterally distorted and closes the clearance between the two faces. In the construction and arrangement shown the rubber ring is composed of a sleeve moulded with radial flanges *D* and embracing a rubber core *E*. It is held in the groove in the valve rotor by its flanges *D* being clamped by an annular plate *F* against the valve rotor, with an annular spacer *G* interposed between the flanges. For extremely high pressures a distortable tightening ring composed of resilient metal, can be used, or the ring may be composed of a rubber core sheathed with metal.—*March* 14, 1951.

AERONAUTICAL ENGINEERING

650,976. March 6, 1948.—VEHICLE BRAKES, Dunlop Rubber Company, Ltd., of 1, Albany Street, London, N.W.1, and Henry James Butler, of the Dunlop Rim and Wheel Company, Ltd., Foleshill, Coventry.

The accompanying drawing shows a drum brake incorporated in an aircraft wheel. The wheel comprises a tyre rim *A* and a hub *B*, mounted on roller bearings on a non-rotating axle *C*. They are integrally connected by radial webs *D*, a gap *E* being provided at one side of the wheel for the brake assembly. A brake drum comprises two annular drum members *F* and *G*, each having an inwardly extending annular flange projecting from one edge. There is an annular ring *H* integral with the webs at the bottom of the annular gap and the flange of the drum member *F* is secured to this ring by bolts. Another annular ring *J* has one end bolted to a tyre-retaining flange integral with the rim, and its other end is bolted to the flange of the drum member *F*, the assembly being so arranged that the two drum members are axially aligned and are co-axial with the wheel. The ends of the members remote from their associated flanges are spaced apart from one another, an annular gap thus being provided. A spider comprising an annular member *K*, having equi-spaced holes so that it may be bolted to a member rigid with the non-rotating axle, is provided. There are three sets of friction pads, pressure plates and fluid-pressure-operated mechanism, each associated with one of the radial arms of the spider. Each set comprises an inner pressure plate *L* and an outer pressure plate *M*. Each of the plates is fitted with a pad of friction material *N* adapted to abut the friction surfaces of the drum members *F* and *G* and shaped to conform to their curvature. A hole which extends radially through the assembly of friction pads and pressure plates has a concave seating at the end in the inner pressure plate. The cylinder *O* of a piston and cylinder mechanism is connected to a source of pressure fluid.



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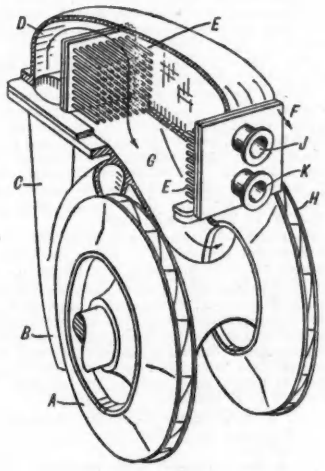
A piston *P* in the cylinder has its piston-rod projecting through a hole and assembly of friction pads and pressure plates. The brake operates as follows. Pressure fluid fed between the piston and the face of each cylinder forces the cylinder radially outwards and the piston radially inwards. This movement forces the friction pad associated with the inner pressure plate into frictional contact with the drum members. Simultaneously movement of the piston and piston-rod forces the friction pad associated with the outer pressure plate into contact with the drum members, the pressure on each side of the drum members being substantially equal.—*March* 7, 1951.

ROTARY AIR COMPRESSORS

651,633. November 4, 1948.—INTERMEDIATE COOLER ARRANGEMENT FOR MULTI-STAGE ROTARY COMPRESSORS, Maschinenfabrik Oerlikon, of Oerlikon, near Zürich, Switzerland.

The accompanying drawing shows the invention in perspective elevation and partly in section. The flow medium leaving the rotor *A* enters a volute chamber *B* and thence reaches a diffuser *C* extending



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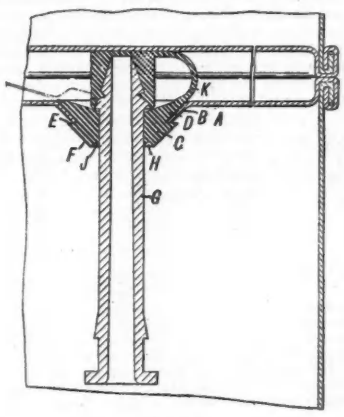
into the cooler chamber *D*, where the conversion of the velocity of the flow medium into pressure takes place. In the chamber *D* the flow medium then changes direction and passes into a cooler tube bundle *E*. The cooler tube assembly can be dismantled in direction *F*. At the rear of the cooler assembly, the flow medium passes through a collecting chamber *G* to the second stage *H*. The cooling water enters the cooler at *J* and passes out at *K*. As the illustrated arrangement is for a four-diffuser blower, repeated three times, almost the whole surface of the compressor is equipped with cooling tubes which permits of very low constructional dimensions radially. The cooler elements can be disposed in the axial direction of the compressor instead of tangentially.—*April* 4, 1951.

MISCELLANEOUS

651,075. January 29, 1948.—DISPENSING CONTAINERS FOR OIL, The Metal Box Company, Ltd., The Langham, Portland Place, London, W.1; John Maxwell Jackson, of the Company's address, and Harry John Bennett, 32, Walpole Road, Downhills Park, London, N.17.

In the drawing the oil container has an end *A* provided with a circular filling opening bounded by a conically disposed flange *B*. Within the filling opening is a grommet *C* of general conical form, the upper part having a face *D* which intimately engages the flange *B*. The engaging face terminates at a shoulder or stop *E* on which the edge of the flange abuts. The lower part *F* of the grommet is also of conical form, so as to facilitate the setting of the grommet within the filling opening. Through the grommet is passed a spout *G* which snugly fits so as to form a seal, whilst the engagement of the flange with the



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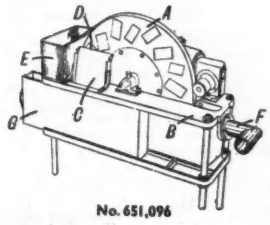
grommet affords a secure seal. The base face of the grommet is grooved at *H* so as to form a flexible lip *J* which prevents egress of oil between the spout and the grommet when the spout is extended. The grommet is formed with a radially extending strip *K* which is flexible and carries at the end a cap with an internal lip which is adapted to snap into a groove about the pouring end of the spout. The bottom end of the spout has a shoulder which engages the inner face of the grommet to limit its extreme extended position. The arrangement described provides a dispensing spout for oil containers, which projects so little above the rim of the can that the bottom of one container can be arranged in abutting relation with the top of another, and form between them a housing of sufficient depth to accommodate the pouring end of the spout, so that minimum space is occupied in transit and the pouring device is protected against damage.—*March* 14, 1951.

651,096. October 27, 1948.—MAGNETIC SEPARATORS, Philips Electrical, Ltd., of Spencer House, South Place, Finsbury, London, E.C.2, and Charles William Verity Davis, Century House, Shaftesbury Avenue, London, W.C.2, and Herbert Wilfrid Westwood, 211, Crookston Road, Eltham Park, London, S.E.9.

This invention relates to magnetic separators for removing magnetic particles from liquid. In operating apparatus of this kind it has been found



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in practice that, whilst removal of magnetic contaminant from the main body of the liquid is very efficient, a certain amount of the liquid may also be entrained with the particles. In the case of a

circulating liquid such as a machine tool cutting oil, this loss may reach undesirable proportions and the object of the invention is to overcome this difficulty in a simple and efficient manner. The drawing shows a rotary magnetic separator constructed in accordance with Patent No. 598,295, in that it comprises a rotatable magnetic disc *A* partially submerged in a restricted flow of liquid in a channel contained within a reservoir casing *B* forming the main body of the apparatus, the disc being characterised by dual scrapers or wipers *C* disposed on each side and having downward inclined faces *D*. The contaminated liquid is fed into the hopper *E* which communicates with one end of the channel, the other end of the channel delivering the cleaned liquid to the reservoir from which it is taken back into circulation by the pipe *F*. The material or sludge removed by the scrapers *C* is delivered into receptacles *G* disposed one on each side of the casing, which can be withdrawn for periodic removal and disposal of the sludge. With machine tool cutting oils which tend to cling to the disc, the scrapers may deliver an undesirable quantity of oil into the receptacles, and to avoid this a pair of squeegees, one on each side of the disc, are arranged to press on the side faces of the disc so as to press or separate excess oil from the magnetic particles adhering to the disc. In a modified form the wiping squeegee is replaced by a roller squeegee. Use may also be made of the improved scraper described in the specification, which acts as a liquid-separating means and by itself removes sufficient excess liquid. With other liquids, however, it may be desirable to employ, in addition, one or other of the squeegee devices. In addition to the improvements above described, each receptacle *G* is provided with an open-topped basket which may be of wire mesh and is arranged to be dropped into the receptacle before the latter is placed in position below its associated scraper. The basket has depending feet so that liquid draining from the sludge collected in the basket remains in the bottom of the receptacle in a comparatively clean condition.—*March* 14, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

British Institution of Radio Engineers

Wed., April 25th.—W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "Some Physical Principles Used in Electronic Equipment," T. Emmerson, 7 p.m.

Thurs., April 26th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppell Street, Gower Street, W.C.1, "An Eight-Channel Transmitter for an Experimental Carrier Wire Broadcasting System," R. G. Kitchenn, 6.30 p.m.

Chemical Society

Thurs., April 26th.—Burlington House, Piccadilly, W.1, "Some Recent Advances in the Chemistry of Natural Products," R. B. Woodward, 7.30 p.m.

Illuminating Engineering Society

To-day, April 20th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, Discussion on "Street Lighting," E. Stroud and P. Crawford Sugg, 6 p.m.

Tues., April 24th.—LIVERPOOL CENTRE: Electricity Board's Service Centre, Whitechapel, Liverpool, 1, "Scientific Relationship Between Illumination and Photography," L. A. K. Carr, 6 p.m.

Wed., April 25th.—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, short talks on the history of lighting development, 6 p.m.

Thurs., April 26th.—NOTTINGHAM CENTRE: Gas Showrooms, Parliament Street, Nottingham, "Interior Decoration and its Influence on Illumination," S. A. Wood, 5.30 p.m.

Incorporated Plant Engineers

Thurs., April 26th.—S. YORKSHIRE BRANCH: Grand Hotel, Sheffield, "Cutlery," W. Dobson, 7.30 p.m.

Fri., April 27th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Lifting Appliances: Their Use and Care," A. S. Wann, 7.30 p.m.

Mon., April 30th.—W. AND E. YORKSHIRE BRANCH: The University, Leeds, "Tractors, Excavators and Civil Engineering Plant," H. LEVERTON, 7.30 p.m

Institute of British Foundrymen

Wed., April 25th.—LONDON BRANCH: Waldorf Hotel, Aldwych, W.C.2, annual general meeting, followed by films, "Castings" and "Forgings," 7 p.m.——BIRMINGHAM BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, annual general meeting, Report of Sub-Committee T.S.23 on The Repair and Reclamation, of Grey Iron Castings by Welding and Burning-On, A. B. Everest, 7.15 p.m.

Sat., April 28th.—W. RIDING OF YORKS BRANCH: Technical College, Bradford, annual general meeting, followed by S. W. Wise prize-winning paper, 6.30 p.m.

Institute of Economic Engineering

To-day, April 20th.—Engineers' Club, Albert Square, Manchester, Speaker, G. H. Jolly, 7.30 p.m.——The Greyhound Hotel, Croydon, "Progress Control," J. Bailey, 7.30 p.m.

Institute of Fuel

Wed., April 25th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, final conference in "A Study of Drying." Sessions commence at 10 a.m. and 2.30 p.m.

Institute of Industrial Supervisors

Tues., April 24th.—DUDLEY AND DISTRICT SECTION: Technical College, Dudley, "Mass and Flow Line Production," F. G. Woollard, 7.30 p.m.——KIDDERMINSTER SECTION: Carpet Trades, Ltd., Mill Street, Kidderminster, "Incentives," R. N. Marland, 7.30 p.m.

Thurs., April 26th.—NEWARK-ON-TRENT SECTION: County Technical College, Newark, "Industrial Administration," F. A. Wells, 7.30 p.m.

Fri., April 27th.—CARDIFF SECTION: Technical College, Cardiff, "Attitude," J. Twomey, 7 p.m.

Institute of Road Transport Engineers

Sun. to Sun., April 22nd to 29th.—Annual tour, 1951, visiting vehicle manufacturers and transport undertakings in the Paris area.

Tues., April 24th.—WESTERN GROUP: Grand Hotel, Bristol, "Trends in Vehicle Design, with Particular Reference to the Commercial Show, 1950," P. M. A. Thomas, 7.30 p.m.

Institution of Civil Engineers

Tues., April 24th.—Great George Street, Westminster, S.W.1, James Forrest Lecture, "Some Unsolved Problems in Civil Engineering," G. A. Maunsell, 5.30 p.m.

Fri., April 27th.—YORKSHIRE ASSOCIATION: Great Northern Station Hotel, Leeds, annual general meeting, 7 p.m.; students' annual general meeting, 6.45 p.m.; followed by "Civil Engineering and Medicine in the Field of Environmental Health," N. R. Beattie, 7 p.m.

Institution of Electrical Engineers

To-day, April 20th.—N.E. STUDENTS' SECTION: King's College, Newcastle upon Tyne, Annual General Meeting and Film Show, 6.30 p.m.——N.E. CENTRE: City Hall, Newcastle upon Tyne, "Lamps and Lighting—A Record of Industrial Research," L. J. Davies, 6.15 p.m.

Sat., April 21st.—N. MIDLAND STUDENTS' SECTION: Yorkshire Electricity Board Offices, Sunbridge Road, Bradford, "Electric Safety," T. J. Wynn, 2.30 p.m.

Mon., April 23rd.—LONDON STUDENTS' SECTION: Great Western Hotel, Reading, "Power Station Practice, with Particular Reference to Earley Power Station," J. E. G. Silvester and M. G. Nash, 7 p.m.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2, discussion on "The Trend of Design of Television Receivers," opened by A. J. Biggs, 5.30 p.m.

Wed., April 25th.—N. MIDLAND CENTRE: British Electricity Authority, Whitehall Road, Leeds, 1, "The Planning of an Electricity Board's Distribution System," G. O. McLean, 6.30 p.m.

Thurs., April 26th.—Savoy Place, Victoria Embankment, W.C.2, "Modern Conceptions of the Ultimate Structure of Matter," Sir John D. Cockcroft, 5.30 p.m.

Fri., April 27th.—SCOTTISH CENTRE: Central Hall, Edinburgh, "Illumination," J. L. Davies, 7 p.m.

Institution of Heating and Ventilating Engineers

Tues., April 24th.—SCOTTISH BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Solar Radiation," I. C. Groundwater, 6.30 p.m.

Fri., April 27th.—MANCHESTER AND DISTRICT BRANCH: Town Hall, Manchester, "Ventilation and Heating of Laboratories," H. Coase, 6.30 p.m.

Institution of Mechanical Engineers

To-day, April 20th.—Storey's Gate, St. James's Park, S.W.1, Discussion on "The Design and Development of the Twin Centaurus Power Plant for the Bristol 'Brabazon,'" J. L. Norton, 5.30 p.m.

Sat., April 21st.—E. MIDLANDS BRANCH: Museum Lecture Room, Priestgate, Peterborough, "Optical Instruments Applied to Precision Measurements in Engineering," J. W. Harrison, 3 p.m.——N.W. BRANCH, GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, annual general meeting, "Some Applications of Oil Hydraulic Power," D. H. Young, 2.30 p.m.——YORKSHIRE BRANCH, GRADUATES' SECTION: The University, Leeds, annual general meeting, "The Modern Direct-Hydraulic System," F. H. Towler, 2.30 p.m.

Tues., April 24th.—BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Performance and Weight of Automobile Petrol Engines," Donald Bastow, 6.45 p.m.

Thurs., April 26th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Centrifugal Pumps in Steam Power Stations," R. Pennington, 6.45 p.m.——WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Wear of Fuel Injection Equipment and Filtration of Fuel for Compression Ignition Engines," A. E. W. Austen and B. E. Goodridge, 6.45 p.m.

Fri., April 27th.—Storey's Gate, St. James's Park, S.W.1, discussion on "The New Factory," J. G. Bulger, 5.30 p.m.

Mon., April 30th.—DERBY A.D. CENTRE: Midland Hotel, Derby, "Prospects of the Gas Turbine Car," Geoffrey Smith, 7.15 p.m.

Institution of Production Engineers

Sat., April 21st.—LONDON GRADUATE SECTION: Visit to National Physical Laboratory, Teddington, 2.30 p.m.

Mon., April 23rd.—MANCHESTER SECTION: College of Technology, Sackville Street, Manchester, "Steam Turbine Manufacture," A. C. Annis, 7.15 p.m.

Tues., April 24th.—LUTON SECTION: Igranic Electric Company, Bedford, "Special Electric Control Gear Applications," R. K. Fleming, 7.15 p.m.——S. WALES AND MONMOUTHSHIRE SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, "Measurement of Productive Efficiency," Walter C. Puckey, 6.45 p.m.

Institution of Structural Engineers

Thurs., April 26th.—11, Upper Belgrave Street, London, S.W.1, "The Design and Construction of a Large-Span Prestressed Concrete Shell Roof," G. W. Kirkland and A. Goldstein, 6 p.m.——WESTERN COUNTIES BRANCH: The University, Queen's Road, Bristol, "The Dome of Discovery, Festival of Britain Site," Gilbert Roberts, 5.30 p.m.

Fri., April 27th.—MIDLANDS COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, annual general meeting, 6 p.m.

Junior Institution of Engineers

To-day, April 20th.—39, Victoria Street, London, S.W.1, "Aluminium as an Engineering Material," E. G. West, 6.30 p.m.——SHEFFIELD AND DISTRICT SECTION: Grand Hotel, Sheffield, "The Science and Practice of Dust Collection as Applied to Industry," G. F. H. Peacock, 7.30 p.m.

Royal Aeronautical Society

Wed., April 25th.—PRESTON BRANCH: Technical College, Corporation Street, Preston, annual general meeting, 7.30 p.m.

Thurs., April 26th.—Institution of Civil Engineers, Great George Street, Westminster, S.W.1, discussion on "Air Travel from the Passenger's Point of View," 6 p.m.

Sheffield Society of Engineers and Metallurgists

Mon., April 23rd.—The University, St. George's Square, Sheffield, film show, 7 p.m.

Society of Engineers

Fri., April 27th.—17, Victoria Street, Westminster, S.W.1, "Some Notes on Domestic Science," F. W. Davies, 6.30 p.m.

Society of Instrument Technology

Tues., April 24th.—Institution of Civil Engineers, Great George Street, Westminster, S.W.1, "Human Control Systems," Sir Frederick Bartlett, 6.30 p.m.

Stephenson Locomotive Society

Sat., April 21st.—SCOTTISH BRANCH: 302, Buchanan Street, Glasgow, "Down the Southern Main," R. A. Savill, 3 p.m.

Contracts

VICKERS-ARMSTRONGS, Ltd., has received from the Orient Steam Navigation Company, Ltd., an order to build a 28,500-ton passenger and cargo liner for the Australian service. The new vessel will have a length between perpendiculars of 668ft, a breadth moulded of 90ft 6in., and a depth moulded of 50ft. The geared turbine propelling machinery, of 42,500 s.h.p., will be constructed by the shipbuilders.

THE ANGLO-SAXON PETROLEUM COMPANY has put in hand a new oil tanker building programme which consists of forty-one general-purpose tankers of 18,000 tons deadweight, and five super-tankers of 28,000 tons deadweight. The grand total amounts to nearly 900,000 tons deadweight and the cost is estimated to be £45,000,000. Thirty-one vessels of the new fleet are to be built in British shipyards, and fifteen in the Netherlands, and it is expected that deliveries will begin next year and that the programme will be completed by 1955. The general-purpose tankers are of entirely new design, and will have an overall length of 557ft by 69ft 3in beam, with a summer draught of 29ft 6in. Four of the vessels will have turbo-electric machinery, of British Thomson-Houston design, and the remainder will be driven by steam turbines of Pametrada design. The maximum shaft horsepower will be 8300, and the normal output 7500 s.h.p., to give a service speed of 14½ knots. The design of the super-tankers is based upon the "Velutina," and they will have a length overall of 643ft 4in by 80ft 5in beam, and a summer draught of 34ft. Geared turbine machinery of 13,000 s.h.p. of Pametrada design will be fitted to maintain a service speed of 16 knots. The orders for the general-purpose tankers have been placed with the following firms:—Cammell Laird and Co., Ltd., five; Harland and Wolff, Ltd., four; R. and W. Hawthorn, Leslie and Co., Ltd., four; Lithgows, Ltd., three; Smiths Dock Company, Ltd., three; Swan Hunter and Wigham Richardson, Ltd., four; J. L. Thompson and Sons, one; Vickers-Armstrongs, Ltd., three; Nederland Dock Company, four; Rotterdam Drydock Company, four; P. Smit, Jr., two; and Wilton-Fijenoord, four. Cammell Laird and Co., Ltd., Harland and Wolff, Ltd., R. and W. Hawthorn, Leslie and Co., Ltd., Swan Hunter and Wigham Richardson, Ltd., and the Nederland Dock Company are each to build one super-tanker.